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Over view on Virtual Manufacturing Device in substation automation

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***Abstract*— New communication platforms between protection equipment and the power grid have resulted from the employment of new technologies in automation and substation protection. With the increased use of these technologies and the resulting development of the IEC61850 standard, new possibilities have emerged, including the potential to use earlier protocols as sophisticated automation equipment. The utilization of IEC61850 capabilities in substation automation, as well as the connection of analogue equipment utilizing virtualization and the benefits of server virtualization for substation automation, have all been considered. This article attempts to answer two questions: first, how to define the Data Attribute of analogue equipment; second, how to define the Data Attribute of digital equipment; Beside insists on using virtualization instead of protocol converter.**

***Keywords- IEC61850, VMD, MMS, Logic Nodes, Virtualization*.**

I. Introduction

The use of digital technology in the protection and automation of high voltage substations has led to the provision of multifunctional tools with serial communication. Initially, serial communication was introduced in proprietary protocols for communication with protection and control IEDs and used in substations. The development of this technology led to the development of IEC standards, one of the most important of which is the standardization of communication between the substation and the control center and the definition of a protocol for communication with power systems protection.

Users of automation standards want an open protocol for all in-function functions such as protection, control and monitoring. Again, this means that the conditions for the development of the substation can be met and expanded without the need for the producer of the previous sections. This is so that different manufacturers' equipment can easily work with each other.

A standard with this feature should be able to cover the following:

- Cover all communications within the substation.

- Ability to work with existing internal functions of the substation

- Support the types of structures used.

- Ability to synchronize with the rapid advancement of communication technology and at the same time the slow growth of equipment applications in the power grid

Given the specific and different activities in the control and protection of the substations, it is necessary to understand how the activities in a power substation were solved so far and now how they will be solved using this standard.

The application solution based on IEC61850 has the following application capabilities [1-4]:

- SCADA in the substation.

- Information that should be sent quickly.

- Communicate with the initial process.

- Design and perform startup tests.

-Maintenance, development and reduction of operation and installation costs

-Improve network security

-Significant reduction in space, wiring and tools

-Send and receive statuses faster

- Data on equipment operating conditions for investment prioritization.

Thus, advanced designs use an integrated architecture for substation protection and automation. New substation automation designs using IEC61850 have the following features:

- Connection of relays and IEDs through local area networks for integration in operation

- SCADA, EMS and HMI substation all use the same data shared on LANs.

- Relays, IEDs, and databases use the same protocol to easily provide users' non-operational information.

- The redundancy of microprocessor relays in completely separate subsets is used to improve their performance.

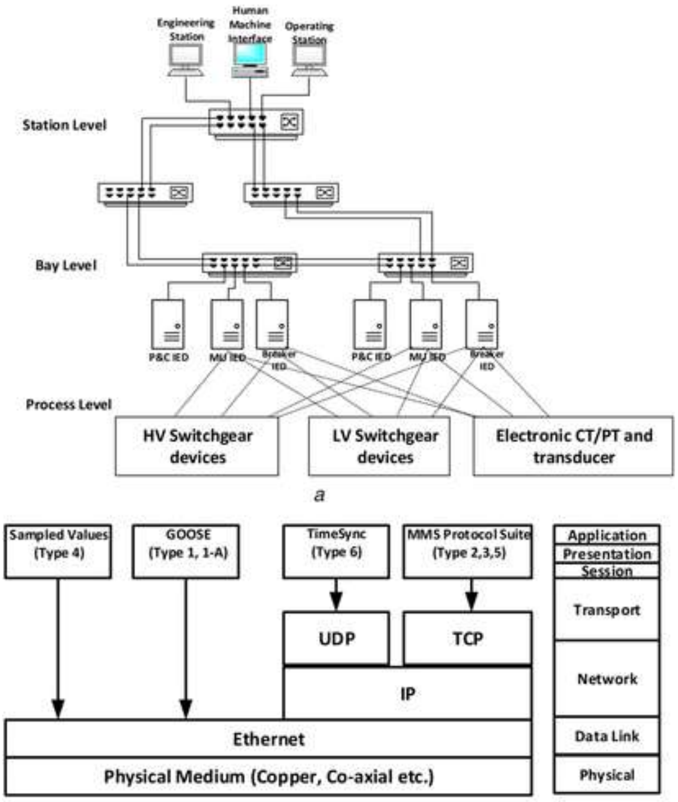

Figure 1: Configuring substation protection using LAN [5]

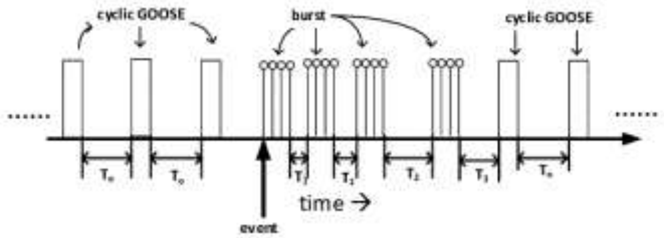

Figure 2: GOOSE message sending intervals with matching capability [5]

In protection designs, as it can be seen in figure 2 the contact or analogue mode from one relay to another may need to be updated every few milliseconds in real-time to work correctly. So one message alone is not enough. Each sender sends a status message or multiple messages multiple times in GOOSE messaging. Sometimes just updating the publishers is enough. The actual message rate is adjustable depending on whether the transfer status or values change. Figure 2 shows the repetition intervals of the message. Note that a specific published GOOSE message may contain several modes. If the states are stable and remain within a specified range, a long signal with a time of one minute is sent. If any state or value that is published in these messages changes, the updated message will be sent without any time change. Also, the time between submissions is reduced to lower values, which are used to update the publishers to the latest.

After the power system is restored, the logic of the GOOSE message in the transmitter relay notices that the states no longer change and returns to the steady-state value. Intervals between messages increase when LAN protection functions return to a steady-state. If a sudden change occurs, the time between sending messages decreases as the distance between messages increases. The logic of controlling the transmission size in the emitter relay or IED is shown in a specific GOOSE message. All of these publishers must be able to detect, interpret, and receive information flows at any rate of data transmission.

A. Client-server model

Servers are B-level IEDs that provide all data to clients in the local mail or telecommunications. The server provides the data as needed or automatically by a report obtained from the server in secure situations. Clients also send commands to exchange data with the server. These commands can be categorized as follows:

- Command issued for the operation of an equipment in the substation

-Correct server behavior when exchanging internal data

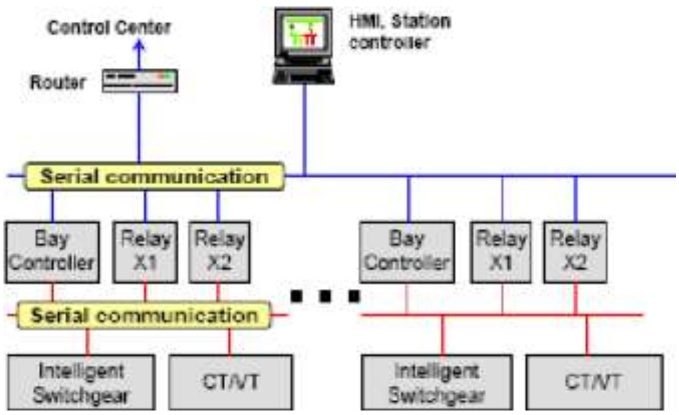

Figure 3: Vertical communication in client-server model [6]

In a client-server connection, the client controls the data exchange. Therefore, client-server communication is very flexible when transferring data. Compared to a Master-Slave system, each server can use multiple clients in one system.

The client-server connection depends on all seven layers of stored data, using a validated transfer layer. As a result, this type of simultaneous communication, which has good reliability, is also time consuming. Therefore, client-server communication is not suitable for data transfer with time constraints (critical and important data such as trip data).

IEC61850 is dedicated to data transfer and monitors the exchange of information between different IEDs with each other and the server and directs the task of processing information by the server.

In [7-13] authors proposed a different methods to protect power grid from collaps. The proposed method in [14,15] would be fruitful for using in power system optimization.

B. Object-Oriented Method

In order to exchange information between different IEDs with each other and the server of this standard, the object-oriented method is used for logical communication between different IEDs. And act as protection. figure 4 shows Vertical data model in object-oriented method.

A logic node is a set of interconnected logic functions so that it has the most straightforward function of the function and cannot be summarized.

For example, to exchange information between protection function and CBF function, the following LNs exist:

-PTRC (protection trip condition) which represents the logic of a protection device that generates digital outputs.

-RBRF, which indicates protection associated with the CBF function.

The exchange of information between these LNs is also modeled as data, which is part of the LN. For example, PTRC stands for Tr with general-purpose data, which is the output of a trip protection device for public trips. This signal is not only used to command the breaker, but also to activate the CBF function.

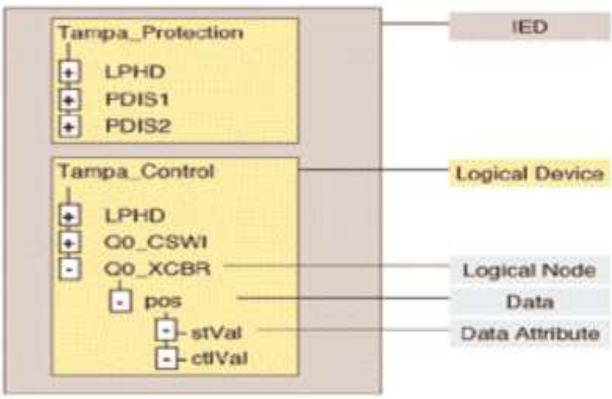

Figure 4: Vertical data model in object-oriented method

C.How to use IEC61850 in high time priority data exchange

In the substation automation system, there are a large number of automatic control and protection functions that require the exchange of high-priority digital information between these functions in different bays. In this context, we can refer to the exchange of data between different BIs for the CBF function or interlocks. These functions have priority due to the need for security and the maximum delay time for sending was a few milliseconds, so it should not be a high priority and does not depend on human response.

Data exchange can be done using the client-server method, but as mentioned, due to the use of this method of seven layers of accumulated data, a lot of time to exchange information consumption.

Therefore, the receiver-transmitter communication method is used exclusively in such a way that the transmitter receives the data in the sending network and different receivers also receive the information according to their needs. Due to the fact that this method does not use the usual standard services for sending data, in a very short time, the data will be transferred.

D. MMS

The use of the SCADA is related to the operation of the network and the sending and receiving of operator commands. The data connection to this program is done from a high level to a lower level. This feature allows the power system to be operated and monitored. For this vertical relationship, the IEC61850 standard uses the client-server method. Servers are B-level IEDs that provide all data to clients in the local mail or telecommunications. The server provides the data as needed or automatically by a report obtained from the server in certain situations. Clients also send commands to exchange data with the server.
MMS models the behaviour of two devices in the client-server model. Physical equipment has the ability to perform both server and client roles simultaneously. In other words, each server acts as a client for its higher level. Thus MMS controls the behaviour of the server. The server includes objects as well as services that can be performed. The MMS server contains objects that the MMS client can access. The VMD (Virtual Manufacturing Device) object is the outermost layer in which the rest of the objects are located and is directly connected to the physical equipment. Figure 5 shows the interaction between client model and MMS server.

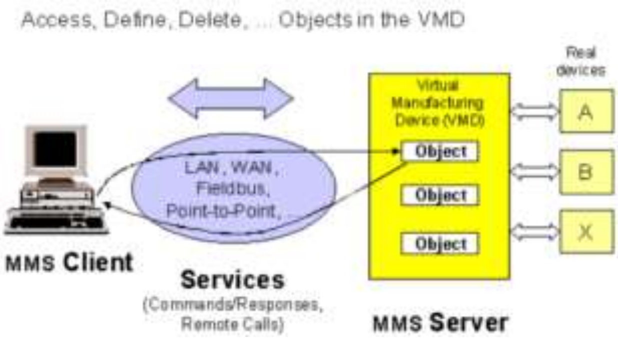

Figure 5: Client model - MMS server
The most crucial feature of MMS is VMD. The VMD model shows how servers behave from the perspective of an external MMS client. MMS allows any application or device to operate

simultaneously as a client and server. In general, VMD includes the following:
Objects (such as variables) that are placed on the server.
Services that the client can use to access and control theseobjects. (Such as reading or writing a variable)
-Server behavior when receiving the required service from the client
The MMS section then provides a summary of the objects defined by the VMD model and the MMS services provided to access and manage these objects. Although the range of things and services is wide, a designated device or program only needs and uses a subset of objects and services that are useful in the context. In the continuation of this article, the details of the VMD model and different objects of MMS and services are examined.
As shown in Figure 6, the VMD represents the actual data and equipment from a client perspective. As a result, the server provides a quasi-standard driver that converts real equipment to virtual or digital mode.
The following modelling definition makes a virtual device clearer:
- If a device has an external existence and is visible, it is called real equipment.
- If a device has an external presence and is not visible, it is called equipment hidden from view or transparent.
- If a device does not exist externally and is visible, it is called virtual equipment.
- If a device does not exist externally and is not visible, it is inaccessible.

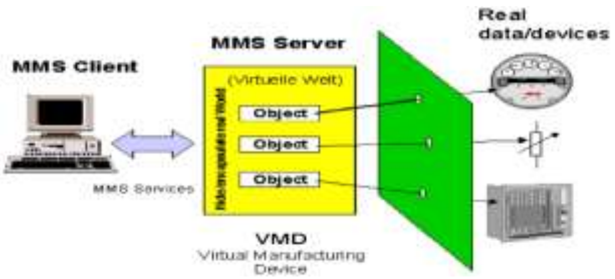

Figure 6: Hiding physical equipment using VMD

In VMD, for example, the task of determining the value of a variable (for example, the Measurement-3 variable whose value is not actually known) will only begin when a variable is read through a measurement transducer. All objects on a server can be present before sending a device, so in this case the objects are predefined.
Apart from using a VMD, data and access to it are always done in the same way. This part is completely independent of the operating system, memory management and programming. The server can be thought of as a communication program that hides the details of real equipment. From the client's point of view, only the server with its objects and behaviors is visible, so the real equipment is not directly visible.
According to the above description, MMS for the server is only a communication aspect that includes objects and services and defines the messages that are exchanged between the client and the server.
VMD fully describes a virtual device. This virtual device shows the actual equipment behavior as long as it is visible. Virtual equipment includes objects such as variables, lists, programs and data locations, LEDs, events, daily reports, and more.
The client can read the VMD Attribute. If the client has no information about the equipment, it can view all VMD objects and their properties using different Get services. Using it, the client can perform the first acceptance test on only one device installed using the Get service. Through that, the client realizes that the installed equipment is the same equipment with the correct model number and name and the expected document number. All other properties, such as the names of variables and their types, can be checked.

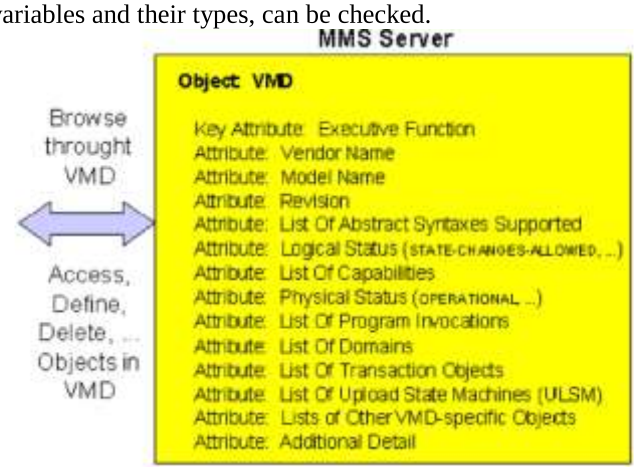

Figure 7:VMD Attributes

The properties of all objects are the specifications of the equipment itself, so as long as the objects are stored in the equipment itself, a VMD is always available correctly and therefore the configuration information of the relevant equipment remains constant. This information can be received directly and online from the equipment and makes the information received by the client always up to date.
MMS defines about 80 functions, which can be categorized as follows:
- Required functions about the contents of the virtual equipment
- Functions to read, report and write values of variables that do not have a specific structure.
- Data transfer functions and applications, to control many other applications and functions.
The unique groups of MMS services and objects are shown in Figure 7. MMS indicates the state of the actual equipment that should be open, or in other words, standardized. An open device must behave like a defined virtual machine. How this behavior is achieved is not visible and is independent of the user who has access to the equipment from outside. MMS does not define any specific local user interface in real systems. These interfaces are separate from the functions used remotely. MMS-related interfaces are a user interface between devices, not within the device, which is defined as an external

interface. Of course, interfaces are always required to perform MMS functions on real equipment.

F. Where VMDs can be placed

VMDs are virtual descriptions of real data and equipment (such as security equipment, metering transducers, and any other automation system or equipment). Depending on the performance of a VMD, there are three possibilities as to where the VMD can be located:

In terminal equipment: One or more VMDs are in real equipment as indicated by VMD. VMD functions have direct access to the data in the equipment. Modeling can be done in such a way that each program field in the equipment is assigned to its own VMD. Unique VMDs are separate.

Gateway or Proxy: One or more VMDs are installed on separate computers (called Gateway or Proxy). In this case, all MMS objects that define real data access in the equipment are in a central part. The data of a VMD after access can be in Gateway memory or should only be retrieved from the terminal equipment if needed. Modeling can be done when each device or program operates with its own VMD. VMDs are separate.

In a file: One or more VMDs are placed in a database on a computer, on an FTP server or on a CD-ROM. Therefore, all VMDs and objects with all their configuration information can be entered directly into engineering systems. For example, a CD-ROM showing the description of the equipment can also be used as a monitoring system with configuration information including names, data types, object specifications, and so on. Before the equipment information is sent, the engineering tools can perform the processing process according to the equipment datasheet specifications. This can also be read online through the respective VMD via the corresponding MMS command.

The unique VMD position feature allows, in addition to support at configuration time, a number of VMDs to be installed on another computer instead of the final system for testing.

Therefore, VMD can have several large automated systems tested in the laboratory and also installed on one or more computers. Using a proper connection, the master client can access and test the VMD in the lab. In this way, all systems can be installed before considering unique equipment interactions.

1. CONCLUSION

This paper introduced the benefits of using Virtual Manufacturing Device in substation automation instead of protocol converter. It is clear that using VMD in the full implementation of IEC61850 in substation automation contributes significantly both technically and economically. In other words, the tree structure of equipment in substation automation and the need for high-speed information exchange between different equipment reveals the need to define a new working model for equipment. Therefore, using the client-server model using MMS mapping and server virtualization (Server Virtualization) and converting physical equipment into digital code makes it possible using new protocols in conventional substation automation.

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