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Protocols for Power System Automation

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ABSTRACT

Electric power utilities, at present, are facing problems of inter probability among intelligent electronic devices supplied from the different companies during the expansion of an existing electric substation. Recently, an attempt has been made to build a universal standard to eliminate the problem of interoperability. In this context IEC 61850 is getting popularity all over the world for flexible data communication across the IEDS in the electric power substation.

1. Introduction

Automation of substation in power industry establish the development of remote monitoring control and electronic device co-ordination in substation. Automation of power substations encounters the challenges of power distribution outages and accidents. Sudden accident like lightning, system faults, create the potential risk factor over the reliability of power supply lead to overcome the faults and accidents develop the standard and appropriate technology. Substation automation is a system to enable an electric utility remotely monitor to control the equipment installed in the substation in the control system high speed microprocessor based RTU & IEDS used for substation automation protection IEDS are installed at the substation to collect the data from the substation data communication from the control room to IEDS in remote location and among the IEDS becomes an important issue to realize the substation automation functions. Various protocols used for tele-control, but none of them fully support the interoperability among IEDS supplied by different venders in the substation.

These protocols are:

(1) Modbus, (2) Modbus plus, (3) DNP3.0, (4) IEC60870.

These protocols are used at utility level, these suffer from some shortcoming and not optimize for communication over Ethernet. In DNP 3.0 data packet losses it context. Data Context provides association of data Modbus and Modbus plus are suitable mainly for serial data communication packet with data element. DNP 3.0 uses the IEC60870-5 define frame (FT3)- looking at the short comings an American standard has emerged in the form of utility communication architecture (UCA) 2.0 further some domain specific features of substation have been added UCA2.0 to make it suitable for substation automation and a new standard IEC-61850 is finally evolved [1] first version of this standard has been published in 2003, 2008 version of this standard is under CDV at IEC, IEC-61850 ensure the interoperability among various substation automation components supplied by different vendors. IEC-61850 is the superset of UCA 2.0 [2].

IEC-61850 is an all-encompassing data communication standard that is suitable for several applications. This paper presents a conceptual adaptation of the IEC-61850 standard for substation automation.

2. Basic Approach

The functions performed by substation automation system are in, general, switch control, data monitoring, protection etc. in IEC-61850, these function is broken into low level function called sub-functions. Each sub-function is performed by the IED installed in the substation.

Each IED can performed one or many sub function. A set of sub- functions is integrated together to realize a substation automation function. These communicate with each other through local area Network in the substation. Specific syntax and semantic are define for communication between sub- functions. All the possible sub function have been standardized in IEC-61580. Information produced and required by it substation is given in the IEC-61850 standard.

3. Development of Substation Automation Standard

Variety of systems, technologies and protocols has been developed throughout the history. Main problem of this area is the fact that many of these protocols and developed system are usually vendor dependent and cannot be adopted as a complex solution. If we analyze this area from the data networking point of view the most important protocols are Modbus, Modbus plus, DNP3 and IEC60870.These protocols still operates at the electronic utility level. System usually serve the selected services and cannot be adopted over the standard and high speed communication technologies like the Ethernet [3]. Ethernet is one of the most important technologies in the networking area. The utilization and interconnection with the industry communication standard is a topical issue and brings many assets. Important Ethernet characteristics is that is part of standardized networking models like ISO/OSI and TCP/IP protocol stack. The independent parts of the substation or the whole substation automation systems can be connected to create the complex system [6,7,9-10].

3.1. Modbus

The MODBUS protocol has gradually become the standard for creation of automation systems in wide area of industrial applications. Recently Modbus support various set of networking technologies including serial communication. Optical or radio networks, RS-232, RS-422 a RS-485 serial communication or the TCP/IP enhancements. According to the transport technologies, MODBUS operates at different layers within the protocol stack model. Following pictures presents possible solution. At the operational level, Modbus works in a response manner. Required function is presented by the sequence code listed in protocol documentation. Modbus is suitable mainly for serial data communication and it is not optimized for communication over the Ethernet. Modbus plus is important enhancement of previous protocol version .Modbus plus can be seen as a complex solution for remote communication in industry area. Adoption of TCP/IP protocol stack extends the use of this protocol. For the connection over the internet, Modbus obtained reserved system port 502.

Modbus/TCP basically encapsulates a Modbus frame into a TCP frame in a simple manner. Transmission control protocol represents the connection oriented and reliable mechanism instead of other industrial or network technologies. Therefore Modbus can make use of the advantages of internetworking technologies and this fit the master and slave nature of Modbus. There are some disadvantages of this protocol. Modbus for example does not

give time stamped events. The sequence of events is missing the time stamp context and also not provides polled report by exception.

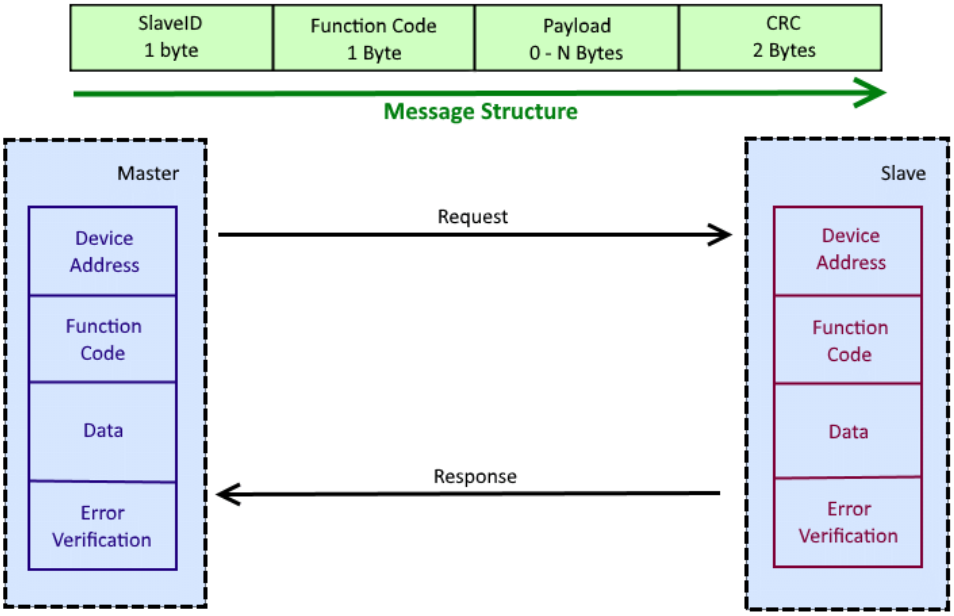

Fig.1. Modbus Communication Protocol Structure

3.2. IEC 60870-5-101

IEC 870-5-101 is an industrial standard developed by the IEC TC57 for electric utility communication between master stations and remote units. The IEC 870-5-101 consist of five parts, like the DNP3 protocol.

IEC 60870-5-101 is one of the IEC 60870 set of standards [4] which is focused on remote control in electrical engineering and power system automation applications. The substandard part 5 provides a communication profile for sending basic remote control messages between two systems via directly connected permanent circuities 60870-5-101 is a structured substandard which provides the definition for the interfaces of RTU (report terminal unit) and IED (intelligent electronic device).It consist of the necessary components and profile definition for vendor's development and ensures the compatibility with other systems. The communication profiles and mechanism are technologically independent, according to ISO/OSI relation model. They act mainly on application a data link layer. At the physical layer allows the selection of compatible standards with RS-232 and RS-485 and also support fiber optics interfaces. The frame specification provides the required data integrity together with the maximum efficiency for acceptable implementation. FT 1.2 represents asynchronous way of communication and can be implemented using standard universal asynchronous recover transmitter ports. This standard also offers fixed and variable block length and single transmission character control procedure. The data link layer specifies if an unbalanced or balanced transmission mode is used together with the link procedures. The selection corresponds with function codes. The address schemes for communication circuit also provided. The link transmission procedures follow the IEC 870-5-2 standards, like other part of the protocol stack, and specify the send commands with confirmation and no replay, request and response message. This protocol stack can be implemented in multi drop bus and point to point networks topology.

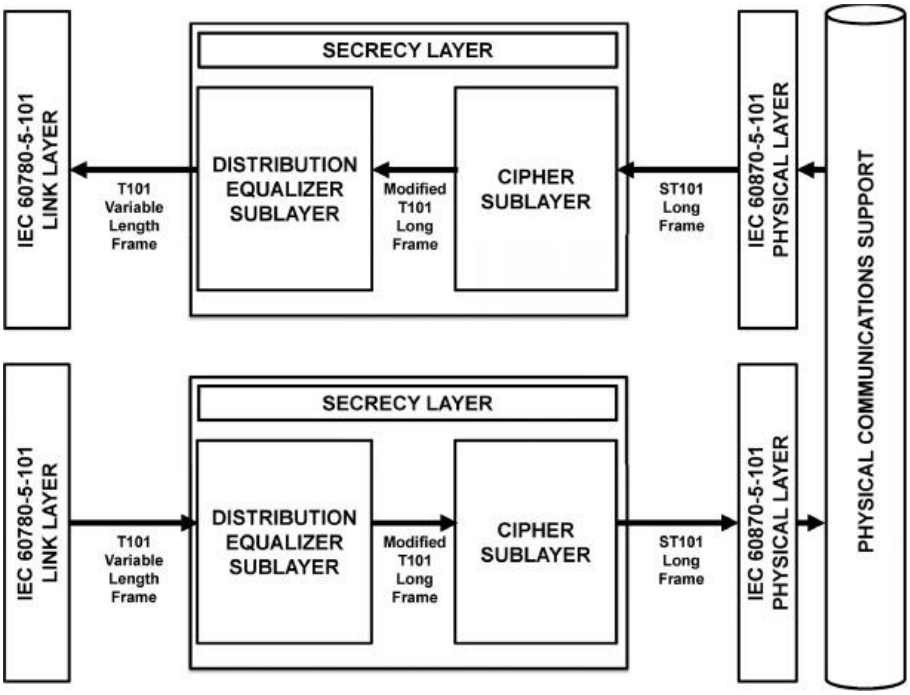

Fig.2. Communication standard IEC60870-5-101

3.3. DNP3

DNP3 distributed network protocol is a protocol stack or a set of communication protocols used for the interconnection of automation systems. Typically is used within the SCADA systems and IED (intelligent electronic devices in the terminology of IEEE TC97 group in the area of power industry.

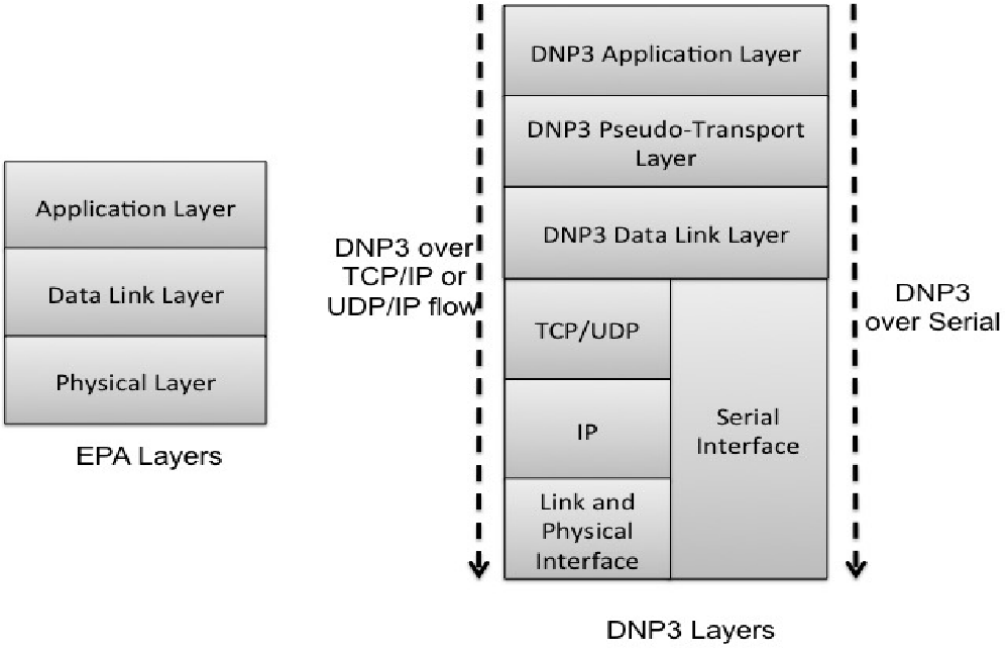

Fig.3. Communication standards of DNP3

DNP3 is not widely used in other industries. DNP3 uses the IEC60870-5 defined frame (FT3) FT3 frame is very similar but not strictly identical. CRC checking and optimal enhancements are the main differences. In the networking terminology according to the ISO/OSI reference model, DNP3 is mostly the layer 2 protocol which

provides multiplexing, error checksum, link control, data fragmentation, basic QOS prioritization and layer 2 addressing schemas. From the transport and application layer perspective, the DNP3 packet loses its own logical context, the interconnection with data units and substation transport event. There were some enhancements developed for example the UCA 2.0 (Utility Communication Architecture Developed).

3.4. IEC-61850

IEC 61850 is the response of previous standard limit. It brings many assets for technology development and implementation. The standardization process bring the convention for object modeling and programing the use of modern networking technologies command scheme, data representation data transfer, encapsulation, and many more IEC 61850 is a huge standard and consist of many substandard . It would be impossible to cover all topics.IEC 61850 communication and data transfer can be realized via serial and modern computer networks, technologies using TCP/IP model and Ethernet encapsulation technique. We recognized two category of communications vertical and horizontal [4]. The collection of IEC 61850 standards cover the methodology for devices integration data encapsulation or network service protocols [5,8, 11-14]. Relationship between the specific sublayers of IEC model as describe as follows:

A. IEC61850-10- conformance testing.
B. IEC61850-6 configuration language for communication in electrical substation related to IEDS.
C. IEC61850-IEC61850-9 specific communication service mapping.
D. IEC61850-7-4 compatible node classes and data classes.
E. IEC61850-7-3 common data classes.
F. IEC61850-7-1 principles and models.
G. IEC61850-5 communication requirements for function and device models.

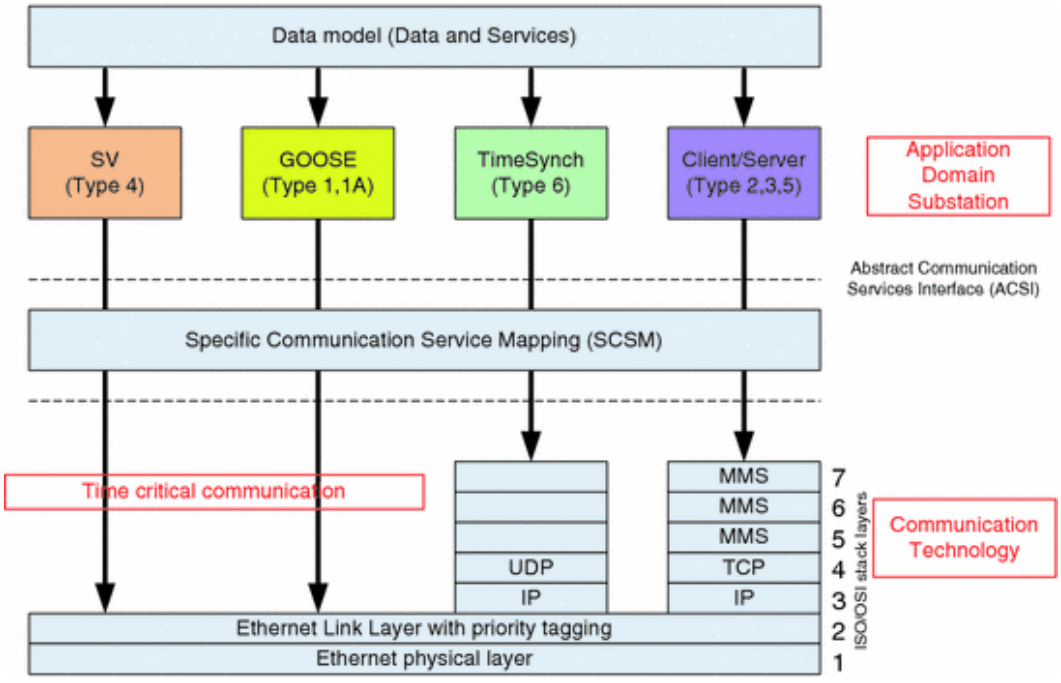

Fig.4. IEC- 61850 communication model

How IEC61850 influence in the devices of a substation? - The integration of MMS protocol and required functionality of IEC 61850-7-2 in the protection manufacturer to add new communication boards or even to use platforms or chipset with more computing power [15].

How the IEC61850 standards affects to the users? - The different equipment manufacturers have include the communication protocols required by the IEC61850 standard and they have to adapt their tools to work with the normative files. They need to know how to identify the capabilities of the IEC61850 equipment available and the information expose in the logical node to able to automate the system to fulfill the requirement application.

Originally the IEC61850 standard applied only to the automation of the electrical substations. Now a day's several groups within IEC are working to define and information model to automate several other energy system areas as-

4. Conclusion

Interoperability is one of the major concern for utilities IEC61850 is attaining the goal of the interoperability through distribution of local nodes in various IEDS. This standard is an all-encompassing data communication protocol that is suitable for several applications. This paper presents a conceptual adaption of the IEC61850 stand for standard substation automation. In this conceptualized model there is better control and monitoring of substation automation.

Declarations

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Competing Interests Statement

The authors declare no competing financial, professional and personal interests.

Consent for publication

Authors declare that they consented for the publication of this research work.

Availability of data and material

Authors are willing to share data and material according to the relevant needs.

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