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Study of Ethernet Technology in IEC61850

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Abstract:
IEC 61850 is an unique substation automation standard which encompasses all the protection, control, measurement and monitoring functions. IEC61850 uses industrial Ethernet technology to provide services like Generic Object Oriented Substation Events (GOOSE), Manufacturing Message Specification (MMS) etc to be implemented at high speed. Using High speed Ethernet technology in GOOSE communication replaces point to point copper wiring between Intelligent Electronics Devices (IED). The study in this paper is conducted for understanding communication in GOOSE protocol using Ethernet technology. The Ethernet frame will analyzed in details in this paper.

Keywords: *IEC 61850, GOOSE, MMS, client/server*

1. Introduction

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and substation related technologies. The IEC 61850 standard has contributed immensely to the way communication and information exchange is implemented within an electrical substation. This fairly new standard aims to ensure interoperability among devices from different vendors [7].

The main idea of standardizing the communication in this protocol is to break down the functions of an IED into core functions called Logical Nodes (LN). Several logical nodes are grouped into a Logical Device (LD) which acts as an access point of the IED. Common information model for each LN and the associated services are standardized which provides the interoperability among IEDs of different manufacturers in substation automation systems [3].

For time-critical events such as protection of electrical equipment, GOOSE messages are exchanged between the devices by means of a local Ethernet network.

2. What Is Client/Server and Publisher/Subscriber

A server displays the data that can be accessed by the client over a TCP/IP connection or the client will receive an event-driven report from the server over TCP/IP. It is a 1:1 connection at protocol level. The connection is initiated by the client for e.g. client needs the data from the server so it sends a request and the server responds with the data. A server may communicate with many clients (one TCP/IP connection between each client and server) [13].

The publisher sends multicast messages to all the devices connected to it. The publisher just sends the message over the network and any device that has a subscriber role picks-up the messages it wants to receive. Each multicast message has an identification number. The publisher does not know who is receiving the messages.

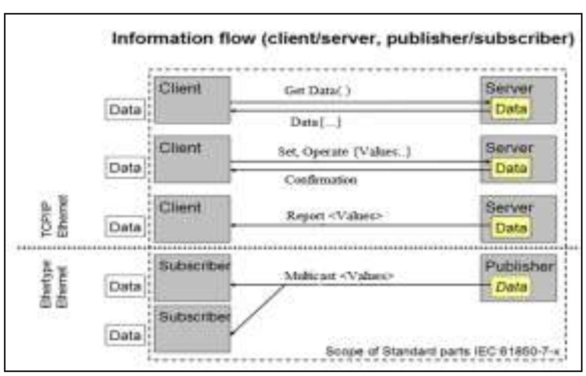

Figure 1: Information flow

3. Ethernet

IEC 61850 standard uses Ethernet as the basis of communication in the automation systems. The speed of the communication link is no longer a hurdle as the recent developments in Ethernet has ranges for 10Mbs to 1Gbps. Ethernet is a universally accepted communication protocol. Ethernet functions at the physical layer of the TCP/IP protocol.

3.1. Ethernet Frame

A data packet on an Ethernet link is called an Ethernet frame. A frame begins with preamble and start frame delimiter. Following which, each Ethernet frame continues with an Ethernet header featuring destination and source MAC addresses. The middle section of the frame is payload data including any headers for other protocols (e.g. Internet Protocol) carried in the frame. The frame ends with a 32-bit cyclic redundancy check which is used to detect any corruption of data in transit.

3.2. Structure

A data packet on the wire is called a frame and consists of binary data. Data on Ethernet is transmitted most-significant octet first. Within each octet, however, the least-significant bit is transmitted first. The table below shows the complete Ethernet frame, as transmitted, for the payload size up to the MTU of 1500 octets. Some implementations of Gigabit Ethernet (and higher speed ethernets) support larger frames, known as jumbo frames. The internal structure of an Ethernet frame is specified in IEEE 802.3.

802.3 Ethernet frame structure								
Preamble	Start of frame delimiter	MAC destination	MAC source	802.1Q tag (optional)	Ethertype (Ethernet II) or length (IEEE 802.3)	Payload	Frame check sequence (32-bit CRC)	Interframe gap
7 octets	1 octet	6 octets	6 octets	(4 octets)	2 octets	42[note 2]–1500 octets	4 octets	12 octets
		← 64–1518 octets (64-1522 octets for 802.1Q tagged frames) →						
← 84–1538 octets (88-1542 octets for 802.1Q tagged frames) →								

Figure 2

PHY transceiver chips used for Fast Ethernet feature a 4-bit (one nibble) Media Independent Interface. Therefore the preamble will consist of 14 instances of 0x5, and the start frame delimiter 0x5 0xD. Gigabit Ethernet transceiver chips use a Gigabit Media Independent Interface that works 8-bits at a time, and 10 Gbit/s (XGMII) PHY works with 32-bits at a time.

3.3. Header

The header features destination and source MAC addresses which have 6 octets each, the EtherType protocol identifier field and optional IEEE 802.1Q tag.

3.4. EtherType or length

This two-octet field can be used for two different purposes. Values of 1500 (0x05DC) and below indicate that it is used as the size of the payload in octets while values of 1536 (0x0600) and above indicate that it is used to represent EtherType. EtherType is used to indicate which protocol is encapsulated in the payload of an Ethernet Frame.

3.5. Payload

The minimum payload is 42 octets when an 802.1Q tag is present and 46 octets when absent. The maximum payload is 1500 octets. Non-standard jumbo frames allow for larger maximum payload size.

Frame check sequence

The frame check sequence is a 4-octet cyclic redundancy check which allows detection of corrupted data within the entire frame.

4. Goose Messages on Ethernet Frame

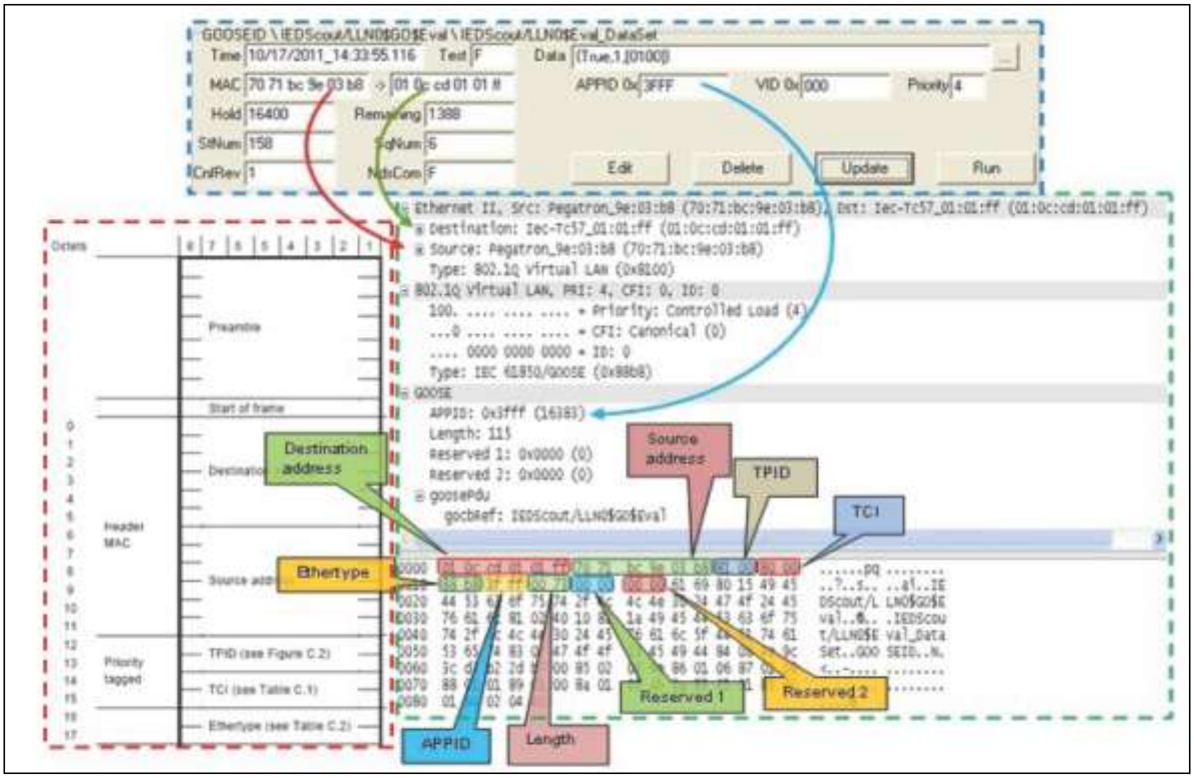

Figure 3

IEC 61850-7-2 defines a generic substation event service which can provide a fast and reliable distribution of input and output data values, including either digital or analogue values. In the IEC 61850-8-1 part of the standard, one of the messages associated with the GSE services are the Generic Object Oriented Substation Event (GOOSE) messages that allow for the broadcast of multicast messages across the Local Area Network (LAN).

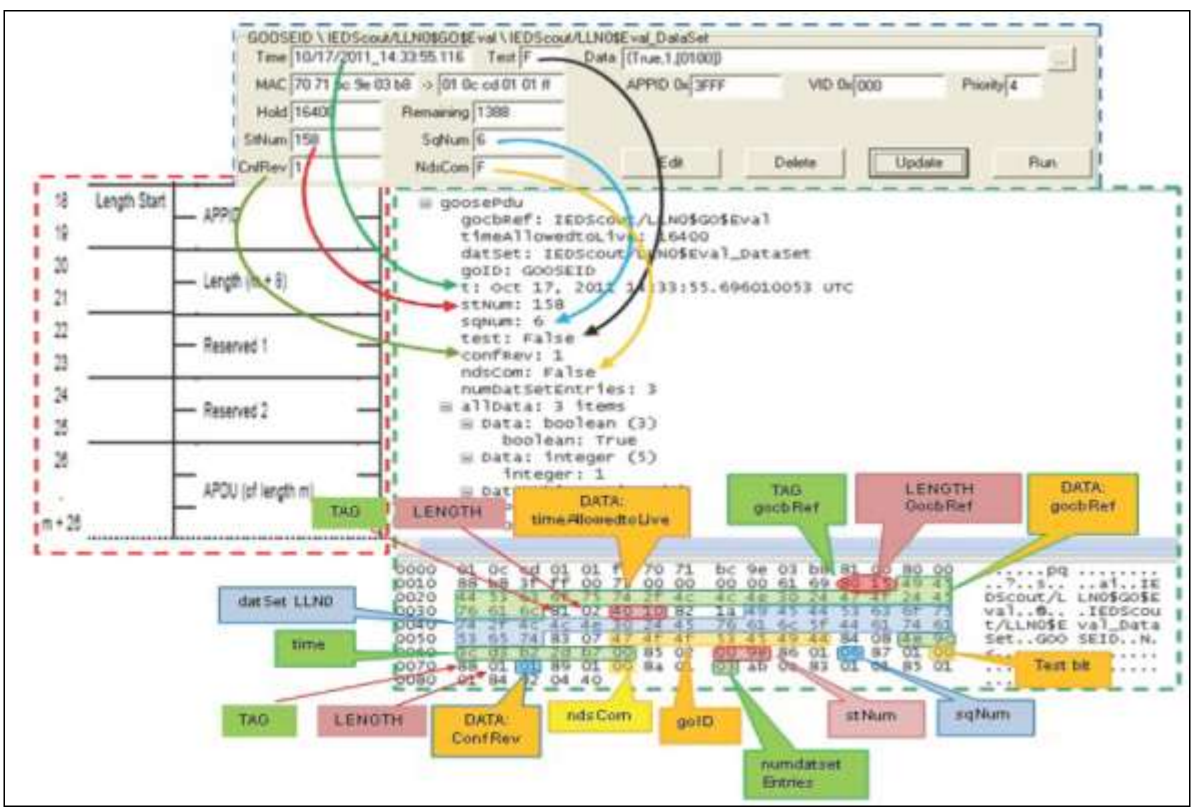

Figure 4

The message exchange method is based on a publisher/subscriber mechanism. When the value of one or several Data-Attributes of a specific functional element in the Data-Set change, the transmission buffer of the publisher will be updated through the local service “publish.req” and the values are transmitted to the transmission buffer combined with a GOOSE message. Specific mapping services of the communication network will update the content of the buffer in the subscribers automatically. New values received in the reception buffer of the subscriber are forwarded to the relevant applications.
The transmission time of the GOOSE message contains three parts:
Transmission =Ta + Tb + Tc

- Ta The local forwarding time in the publisher
- Tb The transmission time from the publisher to the subscriber
- Tc The local forwarding time in the subscriber

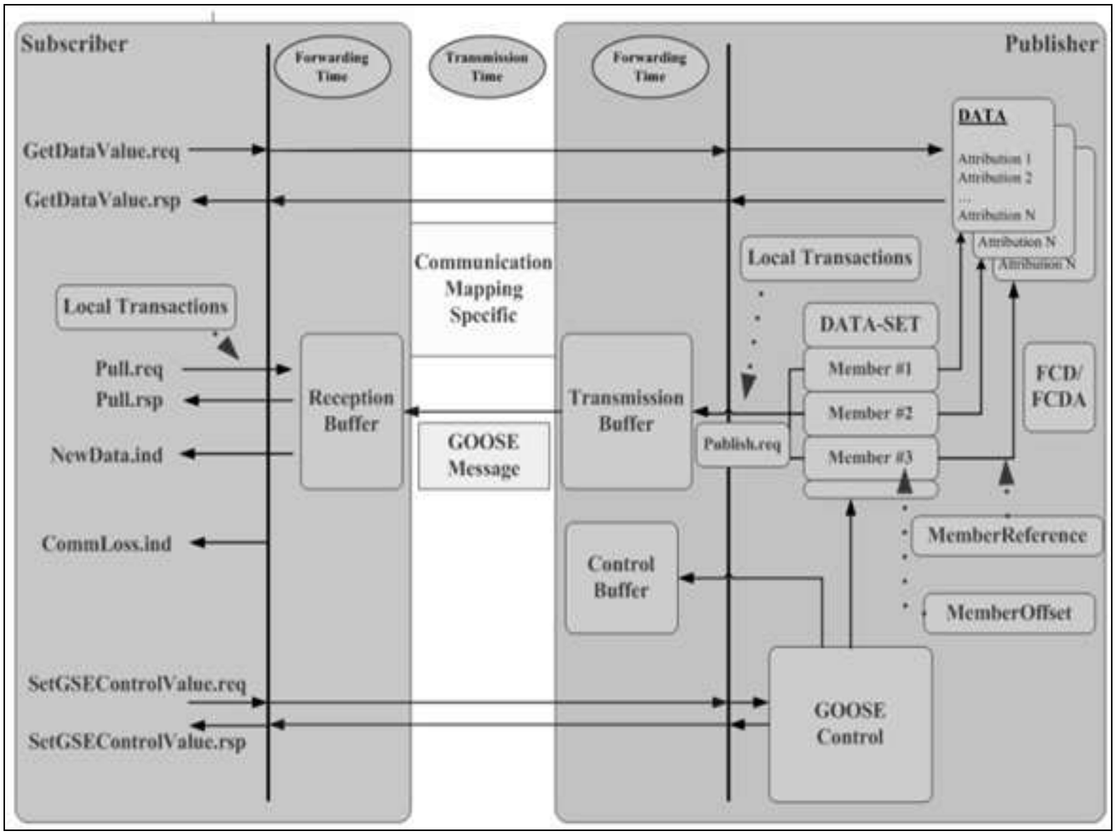

Figure 5: Goose service operation mechanism

Features of the GOOSE service:

→ Handshaking and automatic retransmission Mechanisms to make sure that no GOOSE messages be lost during transmission.
→ Predefined destinations reduce the message’s roaming time on LAN
→ High priority of communication level minimises the transmission delay
→ Peer-to-peer and multicast communication methods allow variety applications
→ Easy to be designed, mapped to current communication technologies through SCSM (Specific Communication Service Mapping) service
→ Transmission time not only depends on the network situations but the IED’s local information forwarding abilities

5. Experimental Results

Simulation of generating GOOSE messages is done using OMICRONS IED SCOUT software within a personal computer (PC). This simulated GOOSE is capture on the NIC card of the PC using a network protocol analyzer like Wireshark. The Ethernet frame consists of the source address which is of the GOOSE generator (in this case PC). The destination address is the multicast address starts with IEC-TC57XXX as shown in the figure.

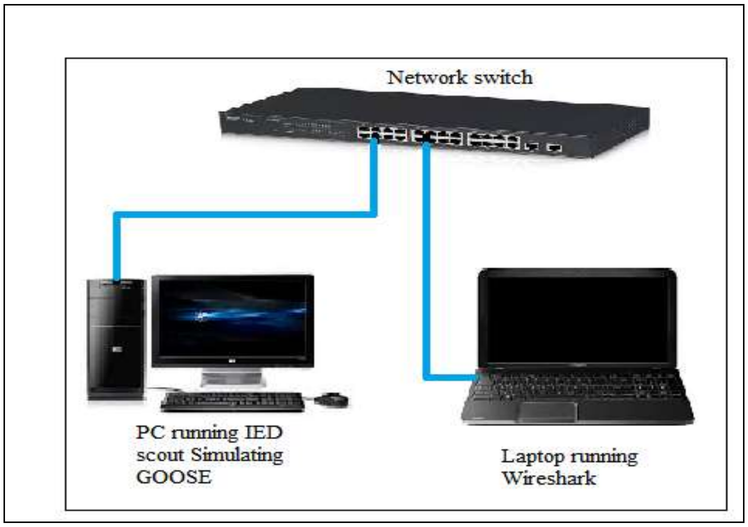

Figure 6: GOOSE simulation setup

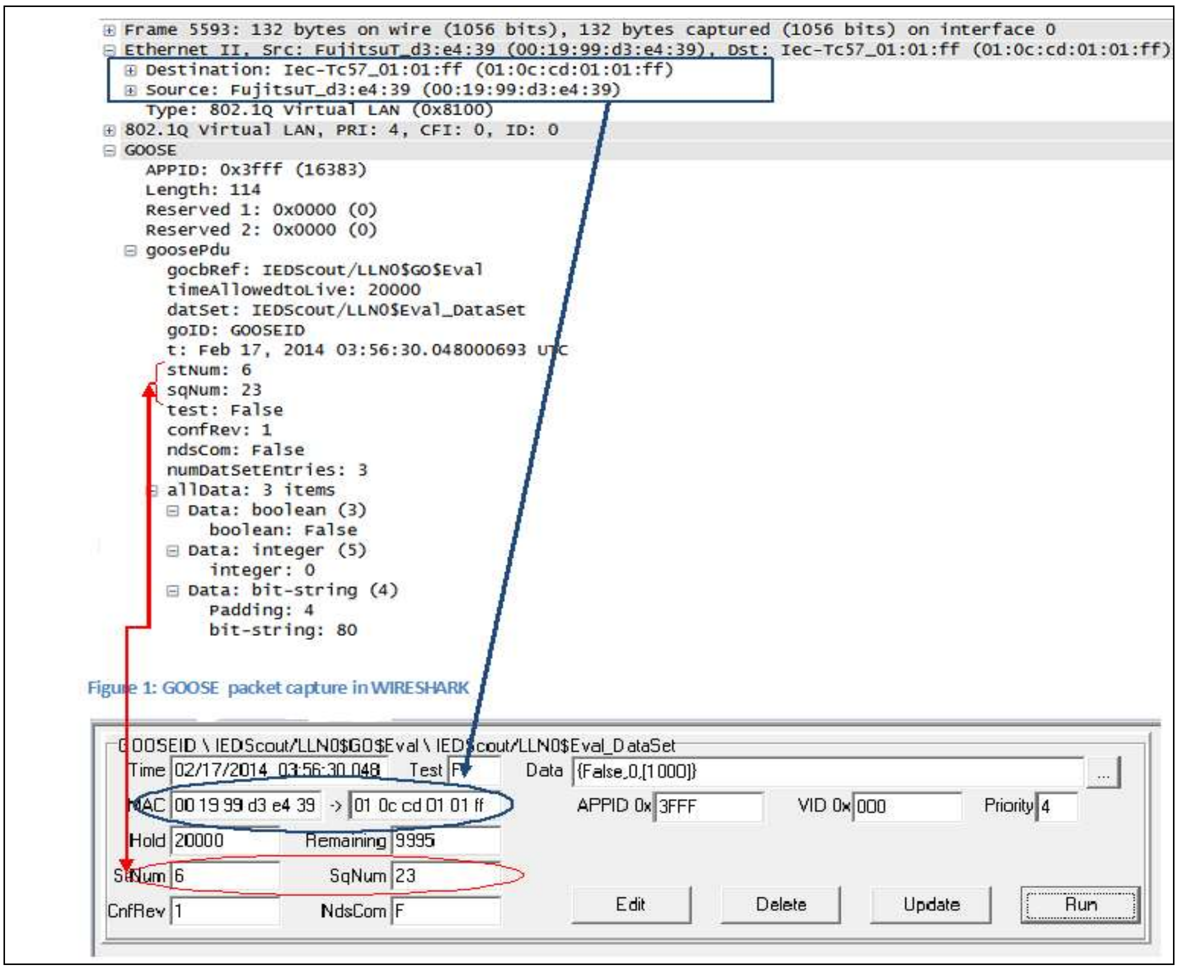

Figure 7

6. Conclusion

The IEC 61850 standard is still in the process of development as changes and expansion to new domain is carried out. In this paper we have successfully investigated the GOOSE message structure and data content to the bit level for complete understanding and the structure is confirmed by experimental simulation. We have also described how the GOOSE dataset appears in an Intelligent Electronic Device (IED). We were able to establish a client server communication between two IEC61850 based devices and successfully exchange the information using Goose protocol of IEC61850 standard.

7. References

i. R. E. Mackiewicz , Member, IEEE "Overview of IEC 61850 and Benefits ".
ii. Byong-Kwan Yoo, Seung-Ho Yang, Hyo-Sik Yang, Won-Yong Kim, Yu-Seok Jeong, Byung-Moon Han and Kwang-Soo Jang, "Communication Architecture of the IEC 61850-based Micro Grid System", Journal of Electrical Engineering & Technology Vol. 6, No. 5, pp. 605~612, 2011.
iii. Victor Manuel Flores and Daniel Espinosa, Julian Alzate and Dave Dolezilek, Schweitzer, "Case Study: Design and Implementation of IEC 61850 From Multiple Vendors at CFE La Venta II" Comisión Federal de Electricidad Engineering Laboratories, Inc.
iv. Rajiv Krishnan, Bapuji Palki ABB Limited, "First experiences with design and engineering of IEC 61850 based Substation Automation Systems in India", CEPSI 2006 Conference, Mumbai, November 6-10, 2006.
v. Il-Hyung Lim, Member, IEEE, and Tarlochan S. Sidhu, Fellow, IEEE, "Design of a Backup IED for IEC 61850-Based Substation", IEEE Transactions On Power Delivery, Vol. 28, No. 4, October 2013.
vi. Ikbal Ali, Sr. Assistant Professor, Senior Member, IEEE, "High-speed Peer-to-peer Communication based Protection Scheme Implementation and Testing in Laboratory", International Journal of Computer Applications (0975 – 8887) Volume 38– No.4, January 2012.
vii. Ivan De Mesmaeker1, Peter Rietmann, Klaus-Peter Brand, Petra Reinhardt "Substation Automation based on IEC 61850", Cigré SC B5 6th Regional CIGRÉ conference in Cairo, November 21 – 23, 2005.
viii. Yingyi Liang Roy H.Campbell "Understanding and Simulating the IEC 61850 Standard ".
ix. L.X. Zhang, Student Member, IEEE, and Nirmal-Kumar C Nair, Member, IEEE "Testing Protective Relays in IEC 61850 Framework" 2008 Australasian Universities Power Engineering Conference (AUPEC'08).
x. http://blog.iec61850.com/
xi. C. Kriger, S. Behardien, J. Retonda-Modiya "A Detailed Analysis of the GOOSE Message Structure in an IEC 61850 Standard-Based Substation Automation System" INT J COMPUT COMMUN, ISSN 1841-9836 8(5):708-721, October, 2013.
xii. http://www.iec.ch/cgibin/procgi.pl/www/iecwww.p?wwwlang=E&wwwprog=dirwg.p&ctnum=1188
xiii. http://blog.iec61850.com/2011/01/what-are-clientserver-and.html
xiv. Klaus-Peter Brand, Wolfgang Wimmer "Modeling interoperable protection and control devices for substation automation according to IEC 61850" Switzerland.