Evaluation of Process to Bay Level Networking Delay in IEC 61850 Substation Communication System

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Abstract: The modern and high-speed Peer-to-Peer IEC 61850 has opened the chance for planning and developing the sampled values that are supported information exchange among IEDs. Over the method bus network, it's important to comprehend the transmission responsibility and real-time performance of SVs and GOOSE messages for all-digital IEC 61850 station automation systems (SASs) protection applications to deal with the responsibility, availableness, and settled delay performance we want to propose a process-to-bay level network model for varied network topologies within the OPNET creator platform. In this paper, we check varied topologies in IEC 61850 and packet delay using mesh and star topologies for LAN and WLAN and conjointly compare the performance of projected theme with an existing methodology for numerous parameters for wireless local area network and LAN by varying packet size.

Keywords: OPNET Modeler, Reliability, SAS, Switched Ethernet Networks.

I. INTRODUCTION

The International Electrotechnical Commission's (IEC) - 61850- methodology bus as a high rate communication network have an honest improved the potential of station automation system (SAS). In every company and world, engineers plan to establish and check the new approaches, taking the benefits of the PC-based technology to create individual check scenario supported modeling and simulating the system parts. However, there square measure several potential system performance analysis ways that like analysis, mathematical modeling, and Test-bed emulating and hybrid simulation [1].

THE IEC 61850 STANDARD

The IEC 61850 customary (Communication networks and systems for power utility automation) defines the peer-to-peer communication that provides services for the exchange of station Events. This unit the GOOSE messages (Generic Object oriented substation Events) supported multicast native space network frames. The foremost evident use of this GOOSE messages is their placement of the conventional wiring to exchange data between bay management and protection units, as an example to implement the interlocking between devices.But once we have got a fast and reliable information communication mechanism between devices, we have a tendency to area unit able to use these messages for different functions as delineated throughout this paper. [2]

IEC 61850 overview

IEC 61850 is a standard for the design of electrical substation automation. IEC 61850 is a part of the International Electro Technical Commission's (IEC) Technical Committee 57 (TC57) reference architecture for electric power systems. The abstract data models defined in IEC 61850 can be mapped to a number of protocols. Current mappings in the standard are to MMS (Manufacturing Message Specification), GOOSE (Generic Object Oriented Substation Event), SMV (Sampled Measured Values) and soon to Web Services. These protocols can run over TCP/IP networks or substation LANs using high speed switched Ethernet to obtain the necessary response times below four milliseconds for protective relaying.
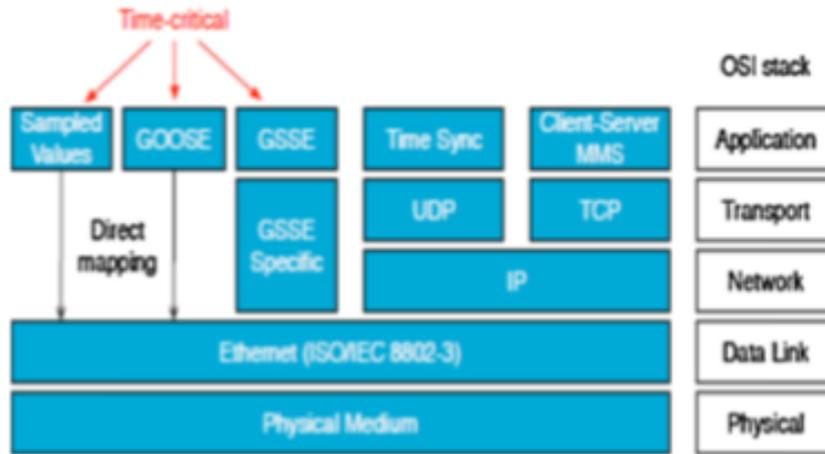
Figure 1 Ethernet communication mapping based on IEC 61850 protocols

Node Model: - The interior structure of a network node will be specified by network model together with workstations, packet switches, satellite terminals, remote sensors [3]. Models were developed in OPNET for protection IED, mu IED, and Breaker IED. The models for CBM control IED and DFR and HMI were taken from existing models and changed consequently. Though of these models were offered for planning the substation, mu IED and breaker IED weren't utilized in the simulations as a result of they do not occur within the station as a part of the network. The node model of the protection IED consists of the traditional OSI seven layers for specifying the FTP traffic within the IED. Beside the OSI layer, 3 specific Process models were developed. These are the Trip source, eth mac into was and therefore the Sink processes. The node model of the protection IED is shown in Fig 2
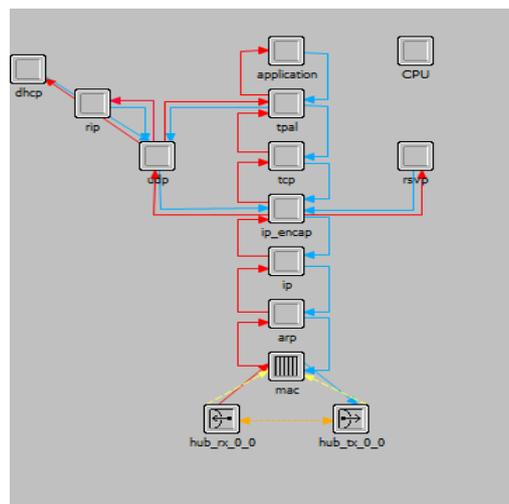

Figure 2 Node Model

Process Model: - During this, we have a tendency to use the method Model Editor. The method Editor controls the functionally of the node editor of the node models created within the Node Editor. Method models area unit described by finite state machines (FSMs), and area unit created with icons that represent states and contours that represent transitions between states. Operations performed in an exceeding state or on a transition area unit delineate in embedded C or C++ code blocks. Every state contains 2 code blocks: the Enter block that's dead because the state is entered and also the Exit block that is dead once the state is left.
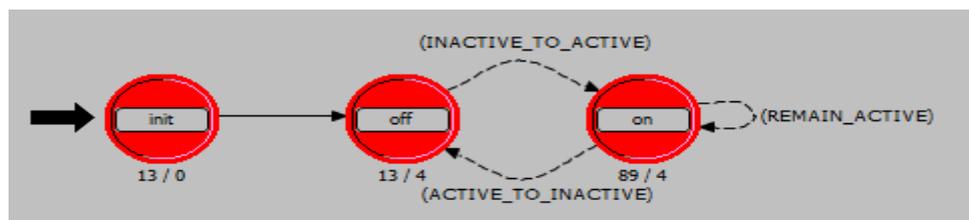

**Figure 3 Protection IED Busty Process Model**
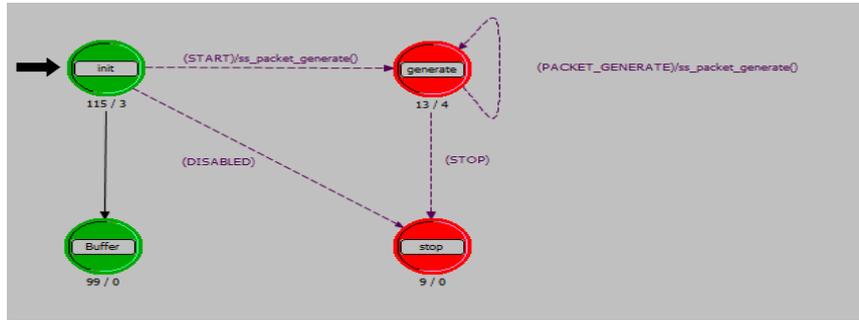
Figure 4 Protection IED Simple Process Model

End to End Delay: - is calculated because the average distinction between the time, each information packet is transmitted by a source entity and therefore the time is received by a receiver entity, then averaged over the entire range of receiver entities is simulated and the delay between the Network using IEC 61850 is drawn.

GSE/GOOSE profiles
GSE (Generic station Events) management model, defined in IEC 61850, provides a quick and reliable mechanism of knowledge transfer over the network. The quality defines a lot of ways in which for communication in station GOOSE and GSE events generally use multicasts for information delivery. GOOSE mechanism group's information into objects and transmits them four milliseconds. It helps to assure the reliability and transmission speed of communication. (GSSE) the mechanism is enhanced by UCA2.0 standing messages [4].

II. LITERATURE REVIEW

Mike Mekkanen et al.[1] Model and Evaluate the MU Performance Based on IEC 61850-9-2LE using OPNET. In this paper modeling of the modern IEDs have been discussed to build SAS process bus network and evaluate the performance of the simulated network under different circumstances using OPNET. OPNET has been shown as an efficient tool for modeling and solving critical performance issues within SAS network. Author had measured latencies based on connecting several MUs within a process bus network to evaluate the limits of capacity of the process bus network critical components such the communication links and the Ethernet switch in which that may facilitate the design and guide the engineers to build the SAS in an efficient way and also shows that the overall of the 19 MUs latency is within the acceptable range (250 μs). However based on adding MUs 20-23 the latency has been increased significantly within scenario two.

Rodolfo PEREDA et al.[2] had evaluated Substation Automation Experiences based on the IEC 61850 GOOSE messages. This paper covers some substation automation experiences supported the IEC 61850 GOOSE messages for AN specific automation function applied to a station topology normally known as 'H' and therefore the use of the GOOSE messages within the communication between management and protection relays and remote I/O modules (RIO). As a conclusion, with this experiences the applying of the peer-to-peer communications, supported the IEC61850 GOOSE messages are implemented, tested and valid in a very real installation, for 2 applications different from therefore most common bay management unit's information exchange

Devender et al. [3] had analysis the reason the performance of WSN based mostly Zigbee network using totally different QoS: End to End Delay, Traffic Received, No of Hops, PAN Affiliation, Packet born are measured. During this analysis work, the performance of Star, Peer to peer and Cluster tree topology are analyzed with the quality of each ZigBee end Devices.The result concludes that in this paper the coordinates are unsuccessful and recovered at a totally different interval of times and transmit power. The results show that at low transmit power end to end Delay, No of Hops, are high and as we increase transmit power and CSD (Channel sensing duration) the Traffic received, PAN affiliation and Packet dropped are augmented. The result additionally shows that the performance of upper values of transmits power and CSD is better than low values.

Josef Horalek et al. [4] The present paper analyses and compares approaches to knowledge communication among the above mentioned protocols with the main specialize in modern standard IEC61850. The paper was created on the idea of expertise whereas implementing knowledge communications for ČEPS a.s., the national distributor within the Czech Republic. The results indicate that remote access to substation automation in power industry is performed in an exceedingly alternative ways. Previous standards like Modbus, DNP3 or IEC 608750-5-101have restricted choices of use. IEC 61850 space covers a wide range of issues, solutions, and technologies; therefore it's difficult to design each project could significantly differ.

III. OBJECTIVES

1. To study the various topologies in the process to bay level networking delay in IEC – 61850 which are available in the literature.
2. To propose a process-to-bay level network model for various network topologies.
3. To compare the performance of proposed scheme with an existing method for various parameters for WLAN and Ethernet varying the data packet size.

RESULT AND DISCUSSION

Simulation Results

In this paper, we look at the results of various types of simulations performed. Various kinds of studies were performed in this thesis, namely delay performance, end to end delay, Traffic sink and Traffic source in which we define

1. Traffic received per bit, bit/sec, packets/bit, and packets/sec
2. Traffic sent per bit, bit/sec, packets/bit and packets/sec having different sizes and using mesh and star topologies were observed. So we present these observations in separate sections.

1. Ethernet delay

Delay is calculated because the average distinction between the time every information packet is transmitted by a source entity and also the time is received by a receiver entity, and so averaged over the overall variety of receiver entities. When simulation of 1020 sec the delay worth of Network using IEC 61850 standard is shown in the below figure
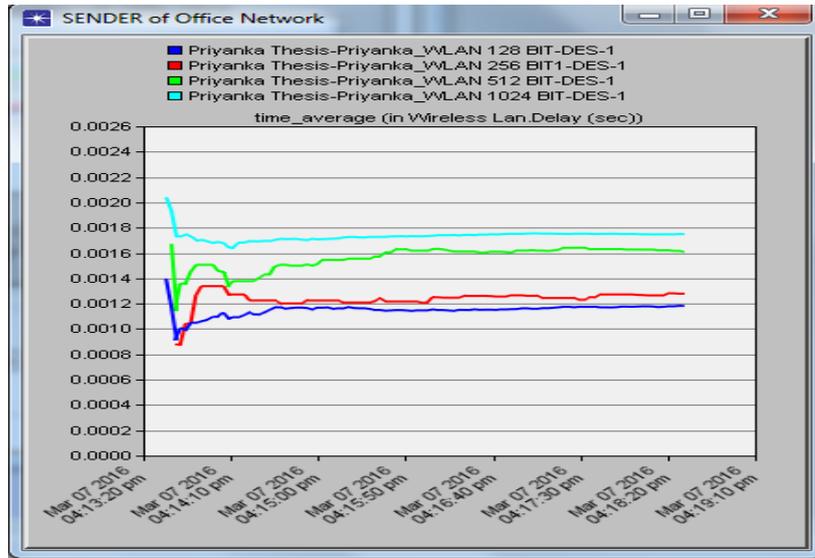
Figure 5 Ethernet Delay

2. Wireless LAN Delay
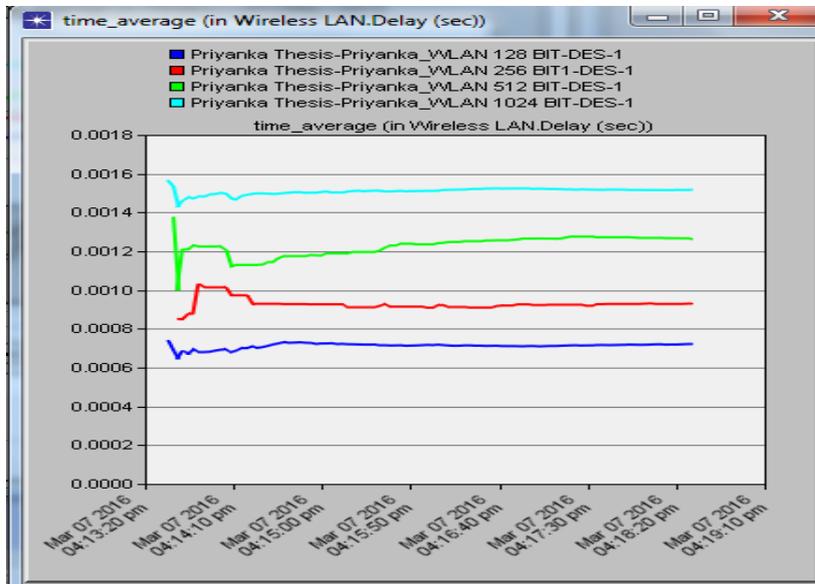
Figure 6 Wireless LAN Delay

3. Delay/sec in Mesh Topology
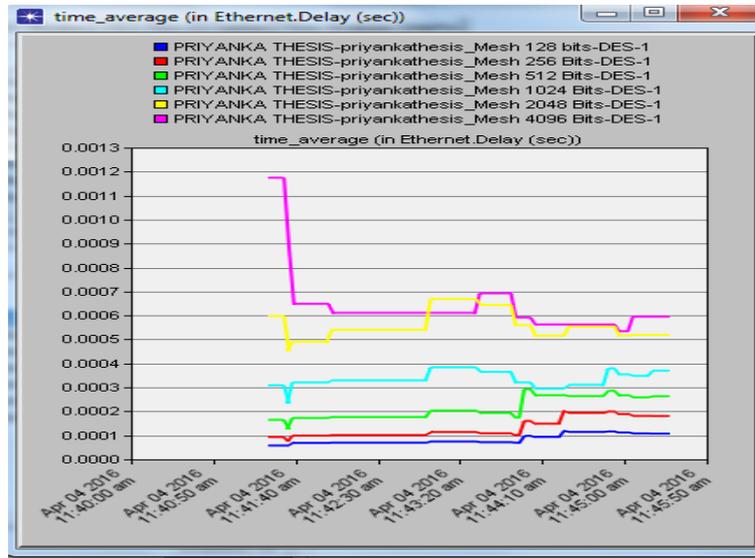
Figure 7 Delay /sec in Mesh Topology

4. Traffic Received in Mesh Topology

This metric consideration with evaluating the overall average of information packets that received by every receiver i.e. overall receiver entities per one second. After simulation of Network using IEC 61850 standard the results of traffic sent bits/sec is given below.
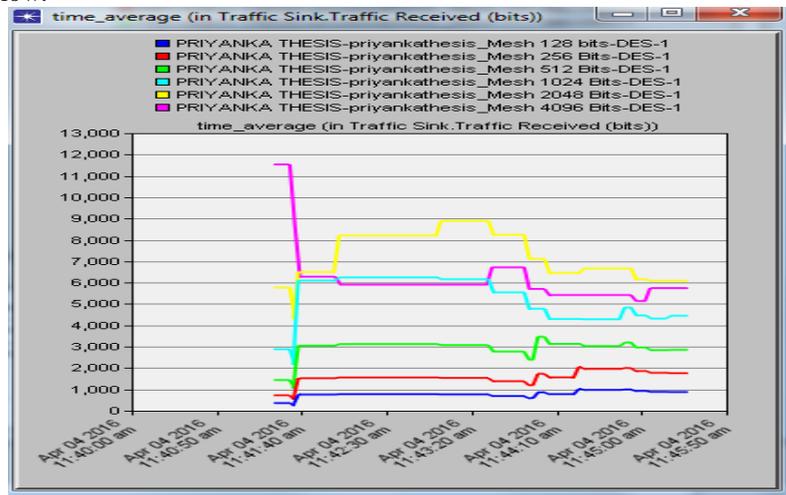

Figure 8 Traffic Received in Mesh Topology

5. End to end delay in Mesh Topology
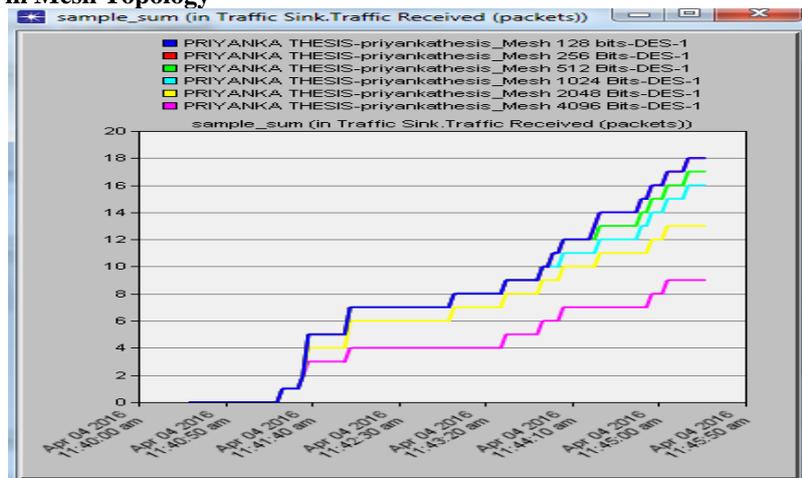
Figure 9 End to End delay in Mesh Topology with sample sum

6. Delay in Star Topology
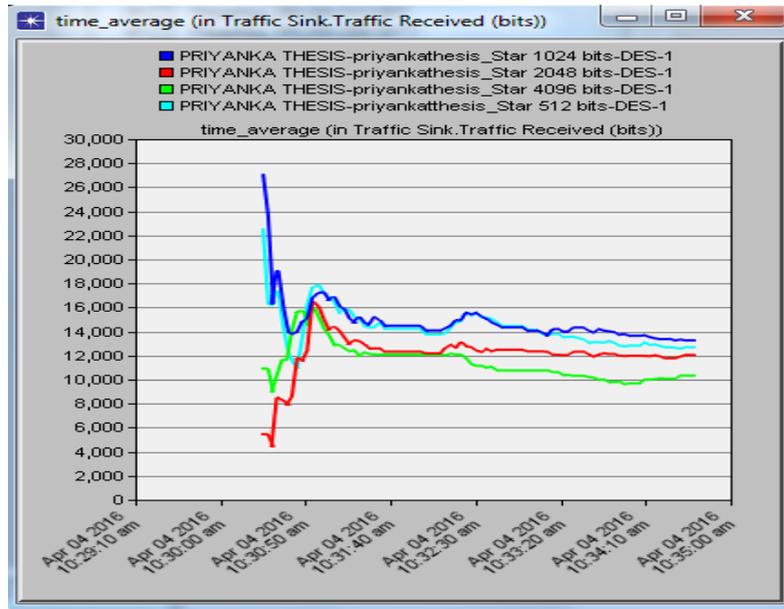
Figure 10 Delays in Star Topology

## 7. End to end delay in star topology
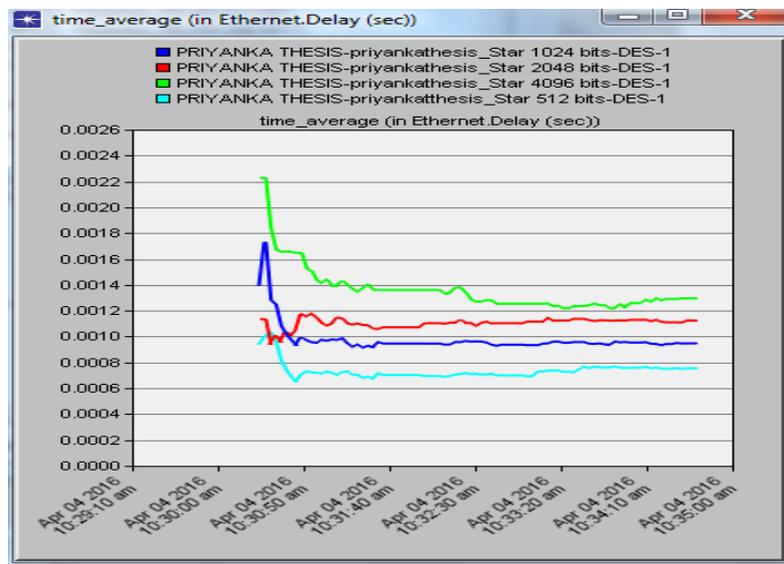
Figure 11 End to End Delay in Star Topology

CONCLUSION AND FUTURE WORK

In this paper, we tend to check out the performance of the station in different topologies like star and mesh topologies in the process to bay level networking delay in IEC – 61850. We tend to focused on the delay characteristics of the priority message and therefore the reliability of the station and proposed new architectures that perform well in each the attributes. We tend to say that in this when the packet size increases then delay decreases. When we compare these topologies on different sizes having large packet size like1024, 2048, 4096 with the star and mesh it performs a lot better in terms of reliability as well as delay also decreases.

IEC 61850 could be a large protocol and implement station over LAN could be a relatively new concept, therefore there are various possibilities for future work. We analyzed solely the communication within the stations. However, smart grid network comprises of diverse substations exchanging information with each other and with NCC. So the model will be expanded to communication outside the station. Even inside the substation, the sensible implementation doesn't include all the messages within the Ethernet network. As an example, the sampled values from MU IED could very well be a part of the network, equally the GOOSE message may also be incorporated into the network. To implement these, the designed models have to be compelled to be expanded. Since these messages also are priority messages, their delay characteristics ought to be studied totally before implementation. The time synchronization designed in all the models during this thesis by using topologies. Studies are created concerning implementing IEEE 1588, precision Time Protocol within the station. Our design will be modified to implement 1588 also. Finally, the wireless models specified uses wireless local area network for communication. However, different wireless technologies like Zigbee, WIMAX and LTE could be explored.

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