Secure Virtual Local Area Network Design and Implementation for Electronic Data Interchange

Jhansi Bharathi Madavarapu[1], Firdous Hussain Mohammed[2], Shailaja Salagrama[3], Vimal Bibhu[4]
Research Scholar, Doctor of Philosophy, Information Technology, University of the Cumberland,
Williamsburg, Kentucky, USA, 40769[1, 2, 3]
Professor, Computer Science & Engineering-School of Engineering & Technology, Noida International University,
Greater Noida, UP, India[4]

***Abstract*—Electronic Data Interchange is a popular platform for sensitive business transactional data transmission over the local to public network. It requires Value Added Network to communicate local data from one endpoint to another. In this paper, we proposed a value-added network design and deployment using the Virtual Local Area Network. The Value Added Network over a virtual Local Area Network eases the burden of managing the network and its functional devices. This proposed network provides the solution of data traffic as per demand required network path for the Electronic Data Interchange applications. This advanced deployment model of Value Added Network over a virtual Local Area Network also offers more robust security to the network entities and traffic. This proposed Virtual Local area network has been deployed with the Cisco environment, and all the specifications have been successfully implemented and tested for optimal security for Electronic Data Interchange. Virtual Local Area Network deployed with four different methods such as transferring packets with backbone, virtual Local Area Network using the tagging method, implementing virtual Local Area Network using Time Division Multiplexing, and by user-defined frame field. All these deployments are successfully done, and the secure platform for Electronic Data Interchange data exchange from one end local network to the other local network has been optimized.**

Keywords*—Electronic data interchange; value added network; virtual local area network; data link layer; time division multiplexing

I. Introduction

Electronic Data Interchange is the common medium of business-sensitive data transmission from one entity to another over a public network such as the Internet. Third-party Value-Added Network (VAN) provides the solution to the local network for EDI application to transmit the sensitive EDI application data from a local network of a business firm to another end of other industries. The virtual LAN is considered the more secure and automated network for EDI applications and data communication between the local network of one business entity to another.

The virtual LAN requires switches to constantly contact the VMPS server, requesting configuration information when an EDI host or EDI network client connects to a switch participating in the virtual LAN network [1][2]. A VMPS database can also be configured with more information to handle more hosts' requests for participation under the virtual LAN. Virtual LAN flexibility can be achieved by connecting more than one EDI host on one dynamically configured port as long as all EDI hosts are part of the same virtual LAN. The defined virtual LAN includes several physical segments per logical subnet. Hence this reduces the burden of management of physical segments and maintenance of network tables.

Virtual LANs are defined with two layers for EDI applications. The layers are virtual LAN Layer 2 and Layer 3 as per the basic working at the respective Open System Interconnection (OSI) layers [3]. Layer 2 virtual LAN is defined based on information at the Data Link Layer (DLL). Each port of the switch constitutes a switch port to form a single virtual LAN segment.

Virtual Local Area Network (Virtual LAN) is a mechanism that allows the same physical network topology to use more than one virtual network simultaneously. The networks of each category are separated for the security enhancement of EDI applications [4]. A special kind of routing is required when one device or workstation wants to reach another device or workstation from one virtual LAN segment to another virtual LAN segment for EDI. The switch determines that the client machine belongs to a virtual LAN. Suppose an EDI client requests a connection from port one on a switch assigned VAN 2; the EDI client cannot change anything behind this as the requested EDI client is indifferent or the same virtual LAN. The assignment of the switch port to virtual LANs is performed in two different ways. One mode of assignment of ports to virtual LAN is followed statistically, which means that the administrator must manually configure each port of the switch to assign the virtual LANs [5].

Some switch ports connect multiple end stations, while others have only one. All the workstations connected to ports associated with virtual LAN share a common broadcast domain, and all workstations of another virtual LAN segment are part of a different broadcast domain. The traffic between the segments of virtual LANs must have to pass through the router.

When multiple EDI end workstations are, by default, part of the same virtual LAN, moving a user to a different switch is considered a problem, with the administrator assigning the end user workstation to a different switch port. This problem is being avoided through the administrator end by establishing a one-station-to-one switch port architecture. This elaborates a good idea behind the usability of virtual LAN technology as per the requirements under the networking and infrastructure optimization of any type of network system for users. This also needs to replace all the hubs currently used under the network by switches, but this poses a problem of cost and expense. However, fewer end stations can be taken to connect directly to each switch port to provide greater flexibility in virtual LAN [6].

Layer 3 virtual LAN uses the network layer addresses to implement virtual LANs. Each end workstation within a given virtual LAN is assigned the same subnet address. The witches read the address and use it to forward packets to destinations under the networks inside and outside to the external world. In this layer, three virtual LAN, a particular subnet is treated as a bridge group which is traffic bridged at layer two within the virtual subnet virtual LAN and routed at layer three virtual LAN [7].

This virtual LAN method segments an extensive network into virtual LANs based on the network layer information contained in each packet coming from the workstations or servers of the network [8]. A switched network acts as a router-segmented network. However, one big difference is that multiple end workstations are attached at the same switch port and still work as members of separate virtual LANs that can be defined for different protocol groups, such as the Internet Protocol (IP).

The main important point for this layer 3 Value Added network is that it is protocol dependent and sensitive to the protocol used with this network. It is also mandatory for the layer three virtual LAN switch to read the different protocol formats that will be used over the virtual LANs. The universal use of the IP makes IP-based virtual subnets the most helpful implementation model of layer three virtual LANs. The switches of layer three virtual LANs use only the subnet portion of the network address to switch the packets at the destination address and do not require much processing at the router level [9].

II. Related Work

EDI needs the secured and advanced virtual LAN to form the VAN for reliable data communication. The data exchange should automate to communicate the data between two or more entities effectively [10]. The entities can use an application based on EDI to communicate the data among them securely and timely, as the proposed work provides the automated communication management of the interchange of data. The VAN based on the virtual LAN provides the secured interchange and adds value, such as prioritizing the particular entity to perform ordered communication.

An inter-organizational system enhances the relationship between the business partners and reduces product development life cycle challenges. This also increases the quality of products. The EDI application creates the VAN over the virtual LAN in each organization to effectively communicate inter-business data [11]. The authors mentioned the implementation strategies for EDI and also classified it. The adoption of EDI, Integration of EDI, and the EDI suitability for small-scale industries over the virtual LAN. The network performance requirements and others are the key aspects for implementing EDI successfully.

EDI and its requirements are constantly increasing in the field of business. Almost all business organizations and government entities prefer EDI as a secured and automated information technology platform to process and communicate vital data among business partners and others. The authors performed a meta-analysis of various research in EDI and VAN and developed a theoretical framework for contextual outcomes associated with adoption to usability [12]. Per management perspectives and standpoints, VAN should have defined guidelines to automate data exchange without considering any network processes.

A real-time and decentralized communication network has interconnecting data nodes that can host the artifacts and services. This type of real-time decentralized network adds value to the artifacts and creates the VAN. The event notification-based VAN with the linked data specification provides advanced services, such as automated communication between the given nodes, which is best suitable for the EDI [13]. The experiments performed by the authors provide an advanced framework that can create a network with nodes that interact with each other. Based on the application scenarios, node registration, re-registration, collaborative certification, and awareness are achieved for value-added services such as EDI and other services.

III. Advanced Design Scheme of Virtual LAN

The advanced design scheme of virtual LAN includes all the aspects of the network, messages, algorithms, and protocols.

A. Proposed Model of Message Format and Encapsulation

Fig. 1 shows the virtual LAN message and protocol layering. Conceptually program used IP to transmit and receive. Virtual LAN message, the header, and data are encapsulated in a frame [14]. Finally, the network interface layer embeds the datagram into a frame sending it from one machine to another. The format of the frame depends on the underlying network topology.

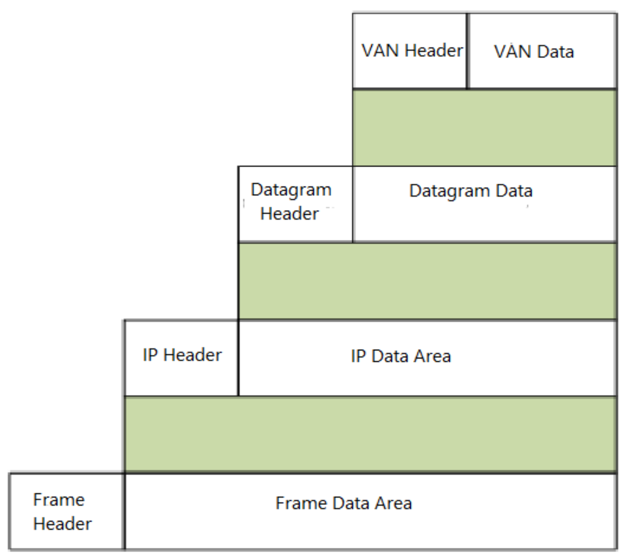

Fig. 1. Virtual LAN message format.

On input, when a packet arrives at the lowest layer of network software and is processed from lower to higher layers. Each layer removes one header before the massage so that all headers are removed by the time the highest layer passes data to the receiving process.

When the net server receives a request for an IP address, it checks for the IP address and sends it to the virtual LAN agent for virtual LAN idea mapping; the virtual LAN agent then checks its node table; if the IP and virtual LAN ID mapping is not available, it sets validity-bit equal to pending and sends back a wait message to the server, the server sends wait message to the node which will be displayed on screen [15].

The virtual LAN manager then replies to the virtual LAN agent with a virtual LAN ID. The virtual LAN agent updates and replies to the server and a node. After random time virtual LAN agent checks its table and sends an updated table to the virtual LAN manager [16]. So that the virtual LAN manager also remains up to date. This is required because after some time, a node that is not in, for some time, its entry from the Ethernet switch is automatically deleted. The second case is when updating is required when a node is in powered condition but whose entry from the cache is removed. It starts reassessing the virtual LAN. Its entry from the node table is updated.

B. Proposed Model of Broadcast by Virtual LAN Manager

The virtual LAN manager repeatedly broadcasts the table, generally after a period of time, which is longer than the previous interval. All virtual LAN agents update their tables after listening to the broadcast [17].

- Virtual LAN Protocol Message Format-1

It is needed to design this format to maintain the node table, as shown in Fig. 2, and details of fields are given Just after Fig. 2.

Preamble	Msg Type	Sec. Bit	HType	HLen	HCPS
		1 VM 0 VA	1 Intra VLAN 1 = 100 Mb Ethernet 2 = 100 Mb Ethernet		6 Ethernet
VAGENT IP Address VA IDDR					
VAGENT HA Address VA Haddr					
VAH addr 32 - 47			VAGENT IP Address VA IDDR		
VMANAGER IP Address – VM iaddr					
VMANAGER HA Address – VMH addr					
VM Address 32- 47					
Table					
END Flag					

Fig. 2. Virtual LAN message format.

Preamble: 1 Octet having left most bit is 1; it indicates b/c.
Msg Type: 0 Indicates this message is from a virtual LAN agent.
Sec bit: 1 Indicates intra-virtual LAN traffic.
Htype: is one octet in length of Hardware address type.
Hlen: 1 octet for hardware address length.
Hops: 1 octet optionally used by relay agents when booting via relay agents.
Vaiddr: Virtual LAN agents IP address filled in by VLAN agent in the request message to virtual LAN manager or server.
Vahaddr: virtual LAN agents hardware address six octets long for Ethernet.
Vmiaddr: Virtual LAN manager's hardware address.
Table: node entries in the table with virtual LAN ID address mapping.
End Flag: indicates the end of the virtual LAN message, a fixed number.

The scheme of the virtual LAN Management is depicted in Fig. 3, assuming that the EDI workstation node in the network is already booted.

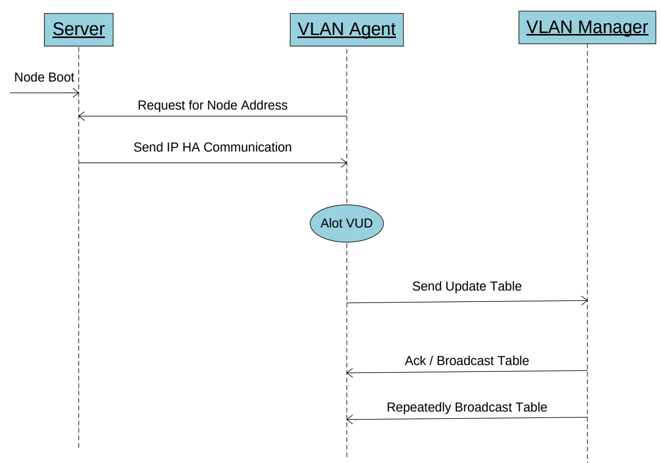

Fig. 3. Scheme of the virtual LAN to manage the EDI workstation.

- Virtual LAN Protocol Message Format-2

Virtual LAN agents request the server for node address; then, the node sends the IP and hardware address combination to virtual LAN agents. Suppose a virtual LAN ID is not allowed on that node. In that case, the agent sets the validity bit equal to pending and sends a wait message to the server. The virtual LAN agent requests the virtual LAN manager for virtual LAN ID allocation. After the virtual LAN ID request from the virtual LAN agent virtual LAN manager checks the table for the virtual LAN ID entry, then allocate the virtual LAN ID and adds it to the table and sets the validity bit equal to clear, and sends the virtual LAN agent [18]. Also, virtual LAN managers repeatedly broadcast the table to all VAN agents with time intervals which is more than the aging time.

The specified design of the virtual LAN message protocol with different fields is shown in Fig. 4 just after it.

Preamble	Msg Type	Sec. Bit	HType	HLen	HCPS
		1 VM 0 VA	1 Intra VLAN 1 = 100 Mb Ethernet 2 = 100 Mb Ethernet		6 Ethernet
VAGENT IP Address VA IDDR					
VMANAGER Address VM iaddr					
Table					
END Flag					

Fig. 4. Virtual LAN message protocol with different fields for VAN.

Preamble: 1 octet. In which if left most bit is 1, it indicates b/c.
Msgtype : 0 Indicates this message is from the Virtual LAN manager is from VLAN manager.
Msgtype: 1. Indicates this message is from a Virtual LAN agent.
Sec bit: -1, Indicates intra Virtual LAN traffic.
Htype: is one octet in length. Hardware address type. For example, 1 for 10 Md Ethernet.
Hlen :1 octet. Optionally used by relay agents when booting via relay agents.
Vaiaddr: Virtual LAN agent's IP address, filled in by the Virtual LAN agent in the request message to the Virtual LAN manager or server.
Table: node entries in tables with address mapping, Virtual LAN ID.
End Flag: Indicates the end of the Virtual LAN message, which is a fixed number.

The scheme of the virtual LAN Management with the dynamic allotment of valid at the time of booting scheme is shown in Fig. 5.

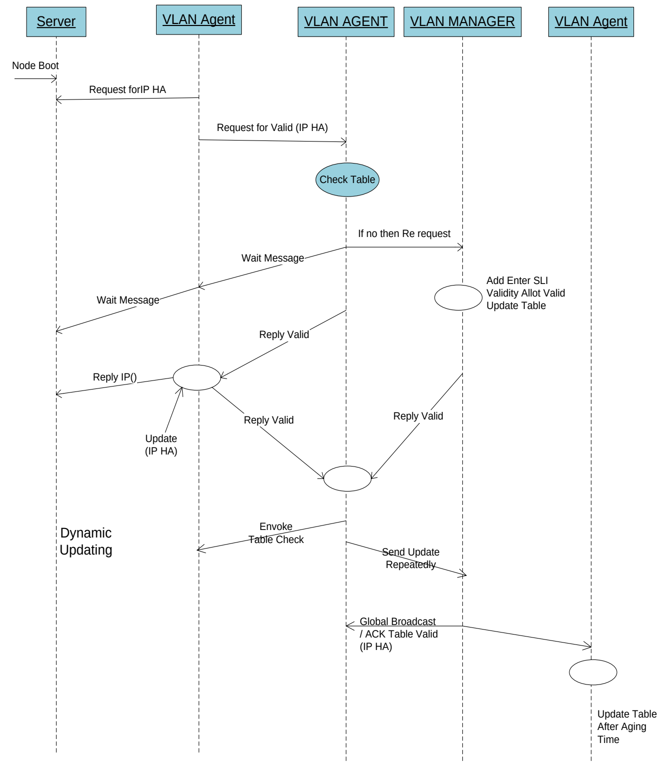

Fig. 5. Scheme of virtual LAN Management with dynamic allotment.

- Proposed Algorithms for Virtual LAN for EDI Services

The message flows between the EDI Node, virtual LAN Agent, and virtual LAN Manager are broadcasted through an algorithm [19] [20]. The design and specification of algorithms are given in Sections III and IV.

IV. Virtual LAN Agent Functional Algorithm

The message between the virtual LAN Agent and Node is defined concerning the algorithmic steps.

1. Check for requests from the node for virtual.
   LAN ID for the node which just came up.
2.
   a. read MAC, the IP address of nodes from the request message.

   b. Send a wait message to nodes.
3. Check the nodes table for
   a. Check mapping of IP, MAC, and virtual LAN ID for node.
4. if (virtual LAN ID for a node is found in the table)
   a. sends it to requesting node.
   b. Accept ACK from the node.
   c. Inform the virtual LAN ID mapping to the virtual LAN manager.

else
   (Evoke virtual LAN manager)
   a. Set validity bit as pending.
   b. Send a request to the virtual LAN manager for virtual LAN ID allotment.

5. Wait for a reply/ack from the virtual LAN manager.
6. Accept virtual LAN ID allotment message from virtual LAN manager.
7. Read the virtual LAN ID from the message
8. Update the virtual LAN agent's node table.
9. send virtual LAN ID to be requesting node.

V. Virtual LAN Manager Functional Algorithm

The algorithm for message flow or broadcast has been the dynamic virtual LAN Agent and Manager.

1. Accept request message from virtual LAN agent for virtual LAN ID allocation. Set the message type equal to zero.
2. Check the entry for the given IP address in the table.
3. If (entry of node's IP address is not present)
   a. allocation virtual LAN ID for that node.
   b. Update the virtual LAN manager table with the allotted virtual LAN ID.
   c. Set virtual LAN ID bit equal to clear.
4. Send virtual LAN ID to virtual LAN agent by setting message type equal to 1.
5. Send a global broadcast on the virtual LAN network to inform all of the updated statuses of the virtual LAN ID table for synchronization.

VI. Proposed Deployment and Implementation Methodology

Meta studies and dynamic virtual LAN design applications are used to collect data. The real-time simulations of dynamic virtual LANs are more helpful in collecting and analyzing the data with the available tool. High-quality lenses tried and tested in industries, are used for the analysis. The Virtual LAN design structure in Cisco Simulator is presented in Fig. 6.

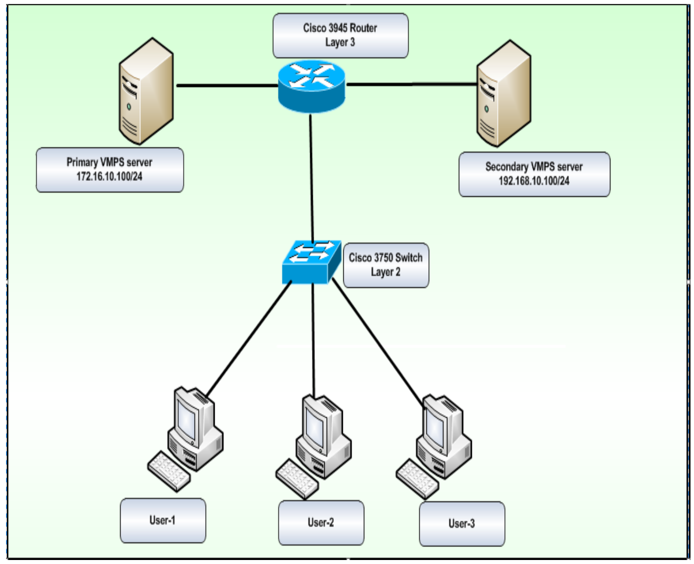

Fig. 6. Virtual LAN design structure in Cisco.

VII. Virtual LAN Implementation & Results

The Ethernet virtual LAN, which functions on layer two, is manually defined by software using which network administrator groups the switch ports into a high bandwidth, low latency switched group [21]. Each virtual LAN with a unique identification number identifies the virtual LAN for network management purposes.

Layer 2 virtual LANs are based strictly on a bridging technique that transmits data using media access control (MAC) and destination addresses. Traffic within virtual LANs is switched using these addresses [22] [23]. Traffic between virtual LANs is carried out by a router that imposes the filtering of packets to provide security and traffic management. The router is either a standalone box-based system or a card integrated into the switch or a node. Routing is handled by a switch that is from the virtual LAN switching logic. The implementation model is given in Fig. 7 with all details of the three virtual LANs, with Cisco Catalyst switch modules with enterprise router interface and external switch interface.

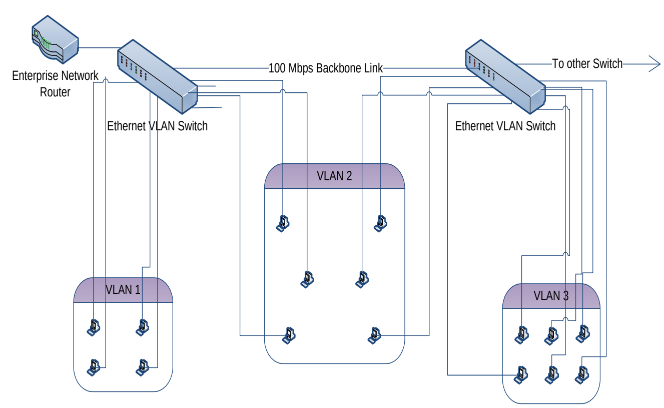

Fig. 7. Virtual LAN implementation using Cisco catalyst switch.

After defining the layer two virtual LANs, each switch reads incoming frames and learns the MAC address associated with each virtual LAN. If the end station or node sends broadcast or multicast frames, it is forwarded to all ports in that end station or node of virtual LAN [24][25][26]. The ports are spread across any number of switches connected to the backbone. All segments in LAN in a port group are bridged, whether they are on the same switch or separated by backbones.

- Transferring Packets over Backbones

Supporting Layer 2 virtual LAN port groups on a switch is transparent. Pure Ethernet switches store MAC addresses and information about which port each address is to. With a virtual LAN switch, a virtual LAN no. and MAC address and port information are stored in the switch's forwarding table. I observed that these tables grow up to 1,000 bytes or sometimes more than this. On layer 2 VLANS, the virtual LAN messages are sent across shared media backbones using frame tagging and time division multiplexing [27].

- Virtual LAN Using Tagging Method

This method places a unique identifier in each frame's header as that frame enters the switch fabric. With the frame tagging process, a short tag is appended at the beginning of every frame that crosses the backbone; the tag tells which virtual LAN the frame belongs to. The switch permanently stores the port group and is valid [28]. Since a virtual LAN number is carried in each frame, each switch examines the identifier before transmitting it to other switches, routers, or end stations [29].

Fig. 8 elaborates on implementing dynamic virtual LAN using the tagging method. Switch such as Cisco Catalyst and tag filed options with switch interface is mentioned under the figure to detail the tagging method for implementing dynamic virtual LAN.

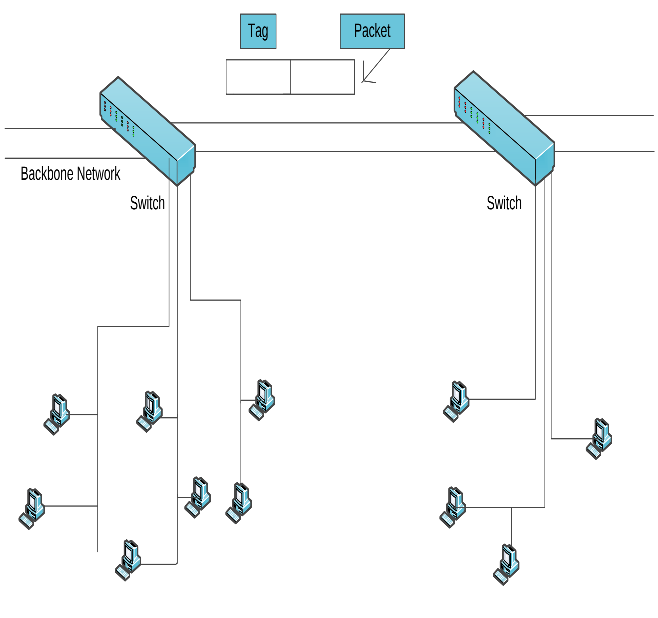

Fig. 8. Virtual LAN implementation using the tagging method.

We received that packet tagging provides a meager latency for assigning and processing frames throughout an enterprise switching fabric, including routers and fast Ethernet backbones [29]. Also, we found one drawback to frame tagging overhead. The frame carries a few bytes of extra baggage.

- Implementation of Virtual LAN using TDM

The implementation and issues related to dynamic virtual LAN using the time division multiplexing mechanisms are considered in this section. Virtual LAN information crosses the campus bus using this technique in layer two virtual LAN. The backbone is divided into 100 Mbps slots, and every virtual LAN is assigned one or more of these time slots, which are used only by virtual LANs. Switches are configured with the information needed to port groups to TDM channels [28][29]. Lan traffic is divided into a separate time slot and reduces the need to use frame tags using which packets are checked. Due to this, network stability increases, and the network load is reduced. As broadcast, one virtual Lan does not affect other virtual LANs. However, I found in this case disadvantage is that other virtual LANs cannot use the bandwidth unused by any Lan. Using this type of virtual LAN requires constant traffic monitoring, ensuring time slots are allocated efficiently. Table I illustrates the implementation data with dynamic virtual LAN using the time division multiplexing mechanism.

TABLE I. VIRTUAL LAN IMPLEMENTATION USING TDM

LAN	Channel Allotted
Virtual LAN 2	Slot 1
Virtual LAN 1	Slot 4
Virtual LAN 3	Slot 2

- Implementation of Virtual LAN User-Defined Frame Field

We studied one different method which uses a layer user-defined frame field in layer 2 Dynamic virtual LAN. Virtual LANs defined by common subnet address, protocol type, and other parameters are defined by the value in the user definition frame field [28]. This creates many possibilities, as virtual can be created based on frame values. As port grouping is eliminated, users can move around; there is no network concern for the port it is connected to.

The problem with the frame field method is that it requires storing information on protocols such as Bit mask offset and another routing (switch) software detail [14]. This method allows different stations on a single switch port to be part of different virtual LANs. Also, the Virtual Lan-based group shares a common server or applications [18]. This aspect of port grouping would require switches that are capable of reading and decoding server names, numbers, and other application-specific fields.

- Using MAC address List

A different dynamic virtual LAN model is designed on the MAC address list, and the list is defined manually. This address list sets up protocol and port-independent switched dynamic virtual LANs. For example, node terminals use non-routable protocols to separate Virtual LANs where each dynamic virtual LAN corresponds to a MAC address list. We found that the MAC address lists technique is more sophisticated than the layer two-port group, as a user can shift to any port in the network and add in proper virtual Lan without reconfiguring the port. The user-defined field under the MAC structure for dynamic virtual LAN MAC is represented in Fig. 5. We observed that this method gives a concrete tool for traffic management. But for extensive networks list becomes lengthy, and if the list is lengthy, it requires more effort.

VIII. Conclusion and Future Work

Virtual LAN is the complex local network structure and more secure local network. The deployment of dynamic virtual LAN needs the design and structuring of the network equipment, such as layer three switches, network routers, and many more. In this paper, we have proposed a deployment and implementation model of virtual LAN for VAN of EDI by considering the different factors. The design is so robust that the network function is optimum per the given details. Also, we tested the network functions concerning functional optimization and found that the designed and deployed network is working per the given specifications.

The proposed research work includes the EDI and VAN over the virtual LAN. The applications and other facts related to the research are very clearly specified and deployed over the Cisco simulation. The functional aspects of the given algorithm for VAN and EDI functionalities are very straightforward. They can be taken as an opportunity to advance the current given processes and get the dynamic protocols with existing automated service-based VAN for EDI. This advancement will bring the opportunity to EDI organizations by reducing the network management overhead. So the organization's cost for information technology support will be drastically reduced.

References

[1] J. Madavarapu, "Electronic Data Interchange Analysts Strategies to Improve Information Security while using EDI in Healthcare Organizations." Order No. 30526513, University of the Cumberlands, United States -- Kentucky, 2023.

[2] Islam, H., Madavarapu, J. B., Sarker, N. K., Rahman, A. (2022). The Effects of Cyber Threats and Technical Problems on Customer's Attitude Towards E-Banking Services. Oblìk ì finansi, 2(96), 58-67. https://doi.org/10.33146/2307-9878-2022-2(96)-58-67.

[3] Andjelkovic, Aleksandra & Barac, Nada & Radosavljevic, Marija. (2017). Analysis of Distribution Channels' Successfulness –The Case of the Retail Chains in the Republic of Serbia. Economic Themes. 55. 501-519. 10.1515/ethemes-2017-0028.

[4] Madavarapu, Jhansi Bharathi, "Payroll Management System" (2014). All Capstone Projects. 82.https://opus.govst.edu/capstones/82.

[5] Mathew, A. and Prabhu, S.R.Boselin, A Study on Virtual Local Area Network (VLAN) and Inter-VLAN Routing (October 18, 2017). International Journal of Current Engineering and Scientific Research (IJCESR), Volume 4, Issue 10, 2017, Available at SSRN: https://ssrn.com/abstract=3055382.

[6] S. P. Chaturvedi, V. Baggan and P. Kumar, "Comparative Analysis of Traditional Virtual-LAN with Hybrid Software Defined Networking Enabled Network," 2020 12th International Conference on Computational Intelligence and Communication Networks (CICN), Bhimtal, India, 2020, pp. 141-146, doi: 10.1109/CICN49253.2020.9242631.

[7] Agwu, Chukwuemeka & Nwogbaga, Nweso & Chukwuka, Ojiugwo. (2015). The Proposed Roles of VLAN and Inter-VLAN Routing in Effective Distribution of Network Services at Ebonyi State University. International Journal of Science and Research (IJSR). 4. 2608-2615.

[8] Kabir, Md. (2020). Design a VLAN (Virtual Local Area Network) Based Network. 10.13140/RG.2.2.29163.57120.

[9] Vladimír Klapita, Implementation of Electronic Data Interchange as a Method of Communication Between Customers and Transport Company, Transportation Research Procedia, Volume 53, 2021, Pages 174-179, ISSN 2352-1465,https://doi.org/10.1016/j.trpro.2021.02.023.

[10] Yunitarini, R. & Pratikto, & Santoso, Purnomo & Sugiono, Sugiono. (2018). A literature review of electronic data interchange as electronic business communication for manufacturing. Management and Production Engineering Review. 9. 117-128. 10.24425/119552.

[11] Narayanan, Sriram & Marucheck, Ann & Handfield, Robert. (2009). Electronic Data Interchange: Research Review and Future Directions*. Decision Sciences. 40. 121 - 163. 10.1111/j.1540-5915.2008.00218.x.

[12] Hochstenbach, P., Van de Sompel, H., Vander Sande, M., Dedecker, R., Verborgh, R. (2022). Event Notifications in Value-Adding Networks. In: Silvello, G., et al. Linking Theory and Practice of Digital Libraries. TPDL 2022. Lecture Notes in Computer Science, vol 13541. Springer, Cham. https://doi.org/10.1007/978-3-031-16802-4_11.

[13] V. Rajaravivarma, "Virtual local area network technology and applications," Proceedings The Twenty-Ninth Southeastern Symposium on System Theory, Cookeville, TN, USA, 1997, pp. 49-52, doi: 10.1109/SSST.1997.581577.

[14] Xiaoying Wang, Hai Zhao, Mo Guan, Chengguang Guo, and Jiyong Wang, "Research and implementation of VLAN based on service," GLOBECOM '03. IEEE Global Telecommunications Conference (IEEE Cat. No.03CH37489), San Francisco, CA, USA, 2003, pp. 2932-2936 vol.5, doi: 10.1109/GLOCOM.2003.1258771.

[15] Makeri Ajiji, Yakubu & Cirella, Giuseppe & Galas, Francisco & Jadah, Hamid & Adeniran, Adetayo. (2021). Network Performance Through Virtual Local Area Network (VLAN) Implementation & Enforcement On Network Security For Enterprise. International Journal of Advanced Networking and Applications. 12. 4750-4762. 10.35444/IJANA.2021.12604.

[16] Narayanan, Sriram & Marucheck, Ann & Handfield, Robert. (2009). Electronic Data Interchange: Research Review and Future Directions*. Decision Sciences. 40. 121 - 163. 10.1111/j.1540-5915.2008.00218.x.

[17] Yalamanchili, Radha Krishna, "International Student Portal" (2014). All Capstone Projects. 85. https://opus.govst.edu/capstones/85

[18] Louis Raymond, Samir Blili, Adopting EDI in a network enterprise: the case of subcontracting SMEs, European Journal of Purchasing & Supply Management, Volume 3, Issue 3, 1997, Pages 165-175, ISSN 0969-7012 https://doi.org/10.1016/S0969-7012(97)00008-7.

[19] Swatman, Paula & Parker, Craig. (2002). Traditional EDI and Supply Chain Management.

[20] Ivan, Kovač & Naletina, Dora & Kuvač, Andrea. (2017). THE SIGNIFICANCE AND IMPORTANCE OF DELIVERY IN ELECTRONIC COMMERCE.

[21] Mukherjee, Momin & Roy, Sahadev. (2017). E-Commerce and Online Payment in the Modern Era. International Journal of Advanced Research in Computer Science and Software Engineering. 7. 1-5. 10.23956/ijarcsse/SV7I5/0250.

[22] Lau F, Hayward R. Building a virtual network in a community health research training program. J Am Med Inform Assoc. 2000 Jul-Aug;7(4):361-77. doi: 10.1136/jamia.2000.0070361. PMID: 10887165; PMCID: PMC61441.

[23] Wang, Jianxin & Peng, Bei & Jia, Weijia. (2004). Design and Implementation of Virtual Computer Network Lab Based on NS2 In the Internet. 3143. 346-353. 10.1007/978-3-540-27859-7_45.

[24] Lee, Jong-Seo & Moon, Il-Young. (2010). Research on Virtual Network for Virtual Mobile Network. Computer and Network Technology, International Conference on. 98-101. 10.1109/ICCNT.2010.68.

[25] Mehmood F, Ullah I, Ahmad S, Kim D-H. A Novel Approach towards the Design and Implementation of Virtual Network Based on Controller in Future IoT Applications. Electronics. 2020; 9(4):604. https://doi.org/10.3390/electronics9040604.

[26] Barla, I.B., Schupke, D.A., Carle, G. (2012). Resilient Virtual Network Design for End-to-End Cloud Services. In: Bestak, R., Kencl, L., Li, L.E., Widmer, J., Yin, H. (eds) NETWORKING 2012. NETWORKING 2012. Lecture Notes in Computer Science, vol 7289. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-30045-5_13.

[27] B. Han, V. Gopalakrishnan, L. Ji, and S. Lee, "Network function virtualization: challenges and opportunities for innovations," IEEE Communications Magazine, vol. 53, no. 2, pp. 90–97, 2015.

[28] K. Pretz, "Software already defines our lives—but the impact of SDN will go beyond networking alone," IEEE. The Institute, vol. no. 4, p. 8, 2014.

[29] Emmerich, D. Raumer, F. Wohlfart, and G. Carle, "Performance characteristics of virtual switching," in Proceedings of the 3rd International Conference on Cloud Networking (CloudNet pp. 120–125, IEEE, Luxembourg City, Luxembourg, October 2014