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ADOPTION OF SD-WAN TECHNOLOGY SOLUTION ACROSS ALL BRANCHES OF BANK MEGA

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ABSTRACT

Information technology has played a crucial role in the development of modern business, including the banking sector. Bank Mega, one of Indonesia's largest banks with 380 branches across the country, faces challenges in connecting communication networks between branches and the head office. The use of Multiprotocol Label Switching (MPLS) as a solution for the Traditional Wide Area Network (WAN) has its drawbacks, such as high costs and limited flexibility. To enhance network performance, cost-efficiency, and security, Bank Mega plans to adopt Software-Defined Wide Area Networking (SD-WAN) technology. This research aims to analyze the impact of implementing SD-WAN technology on the network performance, security, and cost-efficiency of communication links in all Bank Mega branches. The research analyzes the implementation of SD-WAN technology at Bank Mega. The research results show that implementing SD-WAN has a positive impact on network performance, with significant improvements in access speed, response time, and throughput. Network security is also strengthened through advanced security features, although ongoing evaluation is necessary. Additionally, the cost efficiency of communication links increases due to optimized utilization of available communication lines, resulting in up to a 30% annual reduction in operational costs. The recommendations provided include optimal monitoring and management of SD-WAN, integration with additional security systems, regular evaluation of performance and cost efficiency, as well as investment in skills development for Human Resources (HR). Thus, this research offers guidance for Bank Mega and similar companies to effectively leverage SD-WAN technology to enhance the performance, security, and cost efficiency of their communication networks.

Keywords *: Multiprotocol Label Switching (MPLS), Software-Defined Wide Area Networking (SD-WAN), Wide Area Network (WAN).*

1. INTRODUCTION

Information technology has played a pivotal role in the advancement of modern businesses, including the banking sector (Jakšič & Marinč, 2019). In this context, computer networks serve as essential IT infrastructure for banking institutions, such as Bank Mega. Being one of the largest banks in Indonesia, Bank Mega operates 380 branches scattered across the country (Adinugraha, 2023). To establish communication links between these branches and the central office, Bank Mega has traditionally relied on a network known as Multiprotocol Label Switching (MPLS). However, the use of MPLS networks presents several drawbacks, including high costs and limited flexibility (Panhwar et al., 2019).

As network technology rapidly advances, Bank Mega recognizes the need to enhance network performance and cost efficiency by embracing more innovative and modern network solutions. One suitable solution is the adoption of Software-Defined Wide Area Networking (SD-WAN) (Yang et al., 2019). According to Gartner's 2018 report, SD-WAN can assist organizations in improving network performance and cost reduction, making it an effective solution for addressing the increasingly intricate network challenges faced by Bank Mega (Segec et al., 2020). Consequently, Bank Mega has planned to implement SD-WAN technology across all its branches, aiming to enhance performance, network security, and cost efficiency in communication links. This research entails an analysis of the performance,

network security, and cost-efficiency implications of SD-WAN implementation in all Bank Mega branches. These challenges necessitate Bank Mega's ability to adapt to technological advancements. Notably, the application of SD-WAN is not limited to banking; it has found widespread implementation in various industries such as insurance, retail, and the financial sector.

Software-Defined Wide Area Networking (SD-WAN) is a specialized application of Software-Defined Network (SDN) technology designed for connecting geographically dispersed Wide Area Networks (WAN), such as those connecting branch offices and data centers. The implementation of SD-WAN simplifies complexity through features like zero-touch provisioning (ZTP), thereby reducing the risk of human error (Troia, Sapienza, et al., 2021). According to (Troia, Mazzara, et al., 2021), SD-WAN is a technology architecture within the framework of Software-Defined Networking (SDN) that aims to streamline system and network management by separating network hardware from centralized control mechanisms. Utilizing a software-based approach, SD-WAN decouples the data plane within the WAN network and is responsible for managing traffic within the network (Sharma & Tyagi, 2021). This technology is particularly suited for Wide Area Networks (WANs) due to its focus on WAN optimization. SD-WAN facilitates real-time network adjustments using simpler methods, such as Multiprotocol Label Switching (MPLS). One of the notable advantages of SD-WAN is its ability to centrally configure all network elements (Troia, Moreira Zorello, et al., 2021).

SD-WAN introduces the benefits of SDN into enterprise networking, making it a promising next-generation WAN architecture. This approach offers network operators a fresh perspective on network construction. SD-WAN leverages software-defined techniques to connect networks across vast geographical areas, simplifying development and management across different sites. It provides flexibility, centralized control, and monitoring while offering cost savings (Rahmiaty, 2021).

2. LITERATURE REVIEW

Several studies related to the application of SD-WAN have been carried out by researchers used in various fields. The research related to the implementation of SD-WAN is as follows:

In research conducted by (Segec et al., 2020), This research delves into the latest trends surrounding the concept of Cloud-based everything, with a specific focus on Software-Defined WAN (SD-WAN) and its transformative impact on Wide Area Network (WAN) environments, emphasizing a Cloud-centric approach. SD-WAN is replacing traditional solutions, reducing administrative costs, and facilitating operations across multiple WAN connections, including public broadband. The research findings indicate that SD-WAN is a significant topic that has garnered attention from various stakeholders, including organizations, researchers, and analytical institutions (El Kamel & Youssef, 2020). SD-WAN is not a foundational technology but rather a responsive solution addressing user needs and evolving trends. Organizations are keen on constructing efficient and secure communication solutions at cost-effective rates, utilizing the public internet and virtual services. Potential SD-WAN users encompass companies with multiple branches, mobile employees, and an increasing demand for real-time video communications. Furthermore, the education and healthcare sectors also stand to benefit from SD-WAN adoption to tackle communication and security challenges.

In research conducted by (Cao et al., 2017), this research explores the utilization of SDN (Software-Defined Networking) technology to enhance network bandwidth utilization and redundancy. The implemented solution utilizes a high-performance SDN controller with a complex per-flow routing algorithm. This application is capable of redirecting data flows in the event of a link failure. Leveraging OpenFlow technology, this application employs a modified Dijkstra Algorithm to determine the optimal route based on network usage. The research findings conclude that the SDN approach, with OpenFlow technology, offers a straightforward solution for global network control. Notably, companies like Google are interested in resource management efficiency. The OpenFlow architecture provides robust failover redundancy superior to traditional L2 approaches. SDN enables the migration of complex algorithms to high-performance data centers, reducing network costs and enhancing performance. Hardware performance characteristics play a crucial role in the success of OpenFlow in the market.

In research conducted by (Raju M & Rajagopalan, 2022). This research explores the realm of SD-WAN (Software-Defined Wide Area Networking) and its load balancing techniques. SD-WAN is an overlay architecture that enables secure and unified connectivity across multiple transports, all managed centrally with policy control. The study sheds light on the shifts in traffic patterns brought about by the evolution of Cloud computing, which

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traditional MPLS models do not adequately support.

This research aims to provide a more comprehensive understanding of SD-WAN, encompassing its advantages and underlying technologies, including the utilization of load balancing to optimize WAN connections. The findings of this research affirm that SD-WAN is a secure and flexible network solution with centralized control. When combined with MPLS, SD-WAN offers several advantages such as enhanced network management, heightened application prioritization, and the capability to redistribute traffic loads (Majdoub et al., 2020). Furthermore, integrating SD-WAN with load balancing improves productivity and facilitates cloud access, potentially resulting in a higher return on investment.

Research conducted by (Satriawan & Soewito, 2022) emphasizes the significance of implementing information technology in companies to enhance performance, especially following a merger. One of the proposed solutions is the adoption of SD-WAN to streamline network management and boost efficiency. SD-WAN also contributes to the advancement of Industry 4.0 by offering faster services and predictable network performance.

The research findings demonstrate the successful implementation of SD-WAN in addressing post-merger challenges at PT. XYZ, a state-owned insurance company under BUMN Holding. SD-WAN provides seamless monitoring and management through a unified dashboard, enhances network availability with diverse WAN and internet connections, and reduces operational expenses through a Hybrid MPLS and internet approach.

Based on prior research in this field, it can be inferred that SD-WAN is a network technology that centralizes network management, dynamically prioritizes and manages network traffic, and provides enhanced security for various network connections. The implementation of SD-WAN in companies offers benefits such as optimizing network performance, adaptable network expansion, increased network security, and reduced WAN and network costs.

Specifically, the adoption of SD-WAN in the banking sector can bring advantages in maximizing communication cost efficiency, prioritizing critical applications, and enhancing network performance for online banking services and transactions. In the context of this research, the implementation of SD-WAN across all Bank Mega branches will be analyzed with a focus on performance, network security, and communication link cost efficiency.

3. METODE PENELITIAN

A. Conceptual Framework

In this research, the rationale for the research to be carried out is described using a flowchart framework of thought that can be seen in Figure 1.

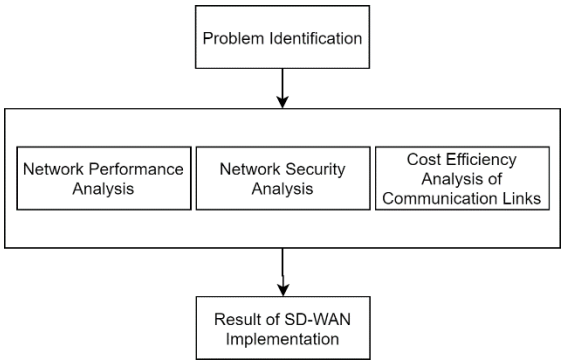

Figure 1. Conceptual Framework

A frame of mind study case covers SD-WAN concepts, network performance analysis, network security, and cost-efficiency link communication.

SD-WAN Concept: In this section, the SD-WAN concept will be explained in depth, including its definition, characteristics, and advantages (Segec et al., 2020). Apart from that, the architecture and working mechanism of SD-WAN will also be explained, including the technology and protocols used.

Network Performance Analysis: This section will discuss how to perform network performance analysis using SD-WAN. Here we will explain the methods that will be used to measure network performance, such as latency, jitter, and packet loss. Apart from that, it will also explain the techniques used to improve network performance, such as load balancing and path optimization.

Network Security: This section will discuss ways to improve network security with SD-WAN. Here we will explain how SD-WAN can help maintain network security, including protection against DDoS attacks, malware, and other attacks. Apart from that, we will also explain the security features available on SD-WAN.

Communication Link Cost Efficiency: This section will discuss ways to increase cost efficiency link communication with SD-WAN. Here we will explain how SD-WAN can help reduce the costs link communication, such as by using multiple VAN links or making use of a link that is cheaper. In addition, the methods used to monitor and manage usage will also be explained as bandwidth.

With the framework of thinking explained above, it is hoped that this research can provide a deeper understanding of the implementation of SD-

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WAN in all Bank Mega branches, especially related to performance analysis, network security, and cost efficiency link communication.

B. Research Stages

In this section, the research stages that will be carried out to achieve the research objectives will be explained. The stages of this research include preparation, implementation, and evaluation. The research stages to be carried out can be seen in Figure 2 below.

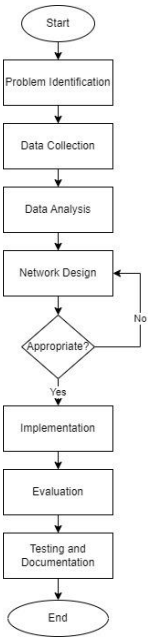

Figure 2. Research Stages

The explanation of the research stages in Figure 2 above is as follows:

C. Preparation

The preparation stage in this research is the initial stage which includes several important steps. First, researchers conducted a literature study related to SD-WAN concepts, network performance analysis, network security, and cost efficiency of communication links. In addition, primary and secondary data related to Bank Mega's network such as topology, devices used, and communication link costs were also collected. At this stage, researchers also identified existing problems in Bank Mega's network before implementing SD-WAN.

In this stage, the researcher explains the data collection techniques used. There are three techniques used: observation, interviews, and documentation studies. Observations involve direct monitoring of SD-WAN implementation in all Bank Mega branches. Interviews were conducted with related parties such as IT managers and network technicians. Meanwhile, the documentation study involves collecting documents related to the implementation of SD-WAN in all Bank Mega branches. This preparation stage provides a strong foundation for continuing this research.

D. Implementation

The implementation stage in this research is the stage taken to implement SD-WAN in all Bank Mega branches. At this stage, researchers will design the SD-WAN system, install devices andsoftware required, as well as network configuration. Apart from that, researchers will carry out trials and validation of the SD-WAN system that has been built at several Bank Mega branches.

E. Evaluation

The evaluation stage is the final step in this research. At this stage, researchers will evaluate the implementation of SD-WAN in all Bank Mega branches by analyzing network performance, network security, and cost efficiency of communication links. The results of this evaluation will be used to test hypotheses and achieve research objectives. With the research stages described previously, it is hoped that this research can provide a deeper understanding of the implementation of SD-WAN in all Bank Mega branches, especially in the context of performance analysis, network security, and cost efficiency of communication links.

F. SD-WAN System Network Design

In designing this system, the discussion includes the process of installation, configuration, and hardware integration to ensure its operation in the network that has been designed. Topology designed for communication between Data Center Bank Mega and branch offices can be seen in Figure 3.

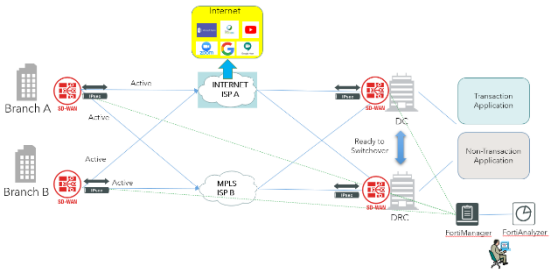

Figure 3. SD-WAN Topology of Bank Mega

Figure 3 shown the SD-WAN topology of Bank Mega which is used for communication between the Bank Mega data center and the Branch Office. This topology is a representation of how each branch can connect to the data center to access transactional and non-transactional applications, as well as showing how branch offices can access the internet. Apart from that, in the process of creating an SD-WAN network, hardware and software are required as listed in Table 1.

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Table 1. SD-WAN Hardware and Software

No	Device	Hardware/Software Type	Function
1	Fortigate Branch	Fortigate 50E	Router & Firewall for Branch
2	Fortigate Data Center	Fortigate 600E	Router & Firewall for Data Center
3	Fortimanager	Fortimanager VM	Management all fortigate SD-WAN
4	Fortianalyzer	Fortianalyzer	Monitoring Traffic & Visibility

SD-WAN Device Implementation

This stage is the implementation of the devices whose topology has been designed in all Bank Mega branches. The following are the tools and implementation stages hardware and software SD-WAN Bank Mega with solutions from Fortigate.

G. Implementation Hardware Branch

The Fortigate 50E in the branch acts as a router and firewall. This device routes to the data center and filters permitted traffic. The process of installing Fortigate on a branch involves the following steps:

1. Routing to data center segments/Ips
2. Advertise branch LAN segment to Fortigate data center
3. Filtering permitted traffic
4. Encrypting traffic to maintain branch communication security
5. Physically connects to internet providers and branch MPLS

H. Data Center Hardware Implementation

The Fortigate 600E is placed in the Bank Mega data center which functions as a backhaul device for connections to all Bank Mega branches. It has the same functionality as fortigate branch does but this is on the data center side. The following are the steps for installing Data Center Hardware:

1. Routing to Segment/Branch IP
2. Advertising Segment Data center Transactional and Non-Transactional
3. Filtering traffic that is allowed in and out
4. Encrypting traffic to maintain the security of branch communications
5. Physically connected to each provider's internet and MPLS backhaul.

I. Fortimanager Software Implementation

Formanager is installed in Bank Mega's data center in the form of a Virtual Machine. As shown in Figure 4, the function of the Fortimanager installation is as follows:

1. As a Single Dashboard Management and Centralize all SD-WAN Fortigate installations
2. As a Monitor of Devices and communication links used
3. To make configuration changes for each Fortigate device

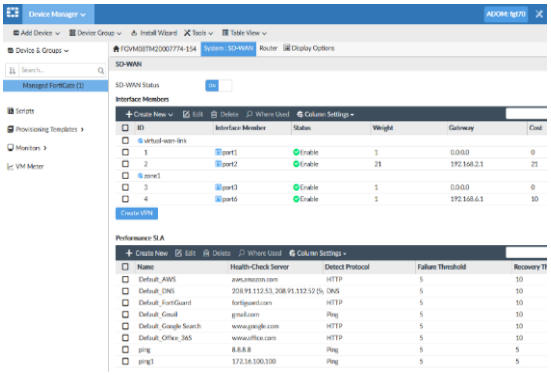

Figure 4. Dashboard Fortimanager

J. Testing and Documentation

At this stage after all installation and configuration is complete on the branch and data center side. Trials and testing of the results of the implementation were carried out. The following are the trials and testing of the connection after installation:

Functionality testing: This testing is to ensure the main features of the SD-WAN are functioning properly. Such as managing communication routing between IP in the branch and IP in the data center.

Capacity testing: This testing is to ensure that SD-WAN can handle large traffic volumes without any disruption or interruption.

Redundancy Test: This test is carried out to ensure redundancy between each communication network used. In this case it uses the MPLS Network and the Internet. So that if a disruption occurs on one of the links, it can be handled by one of the links.

Security Testing This test is to ensure network security by filtering permitted and unauthorized traffic. Apart from that, it also encrypts communication packets. This testing can be done by performing penetration testing (Pentest).

Operational Trial This testing is carried out by carrying out branch operations. From teller activities, backend as well as ATMs at the branch.

K. Evaluation

At this stage, after testing all SD-WAN systems running well, evaluations will be carried out periodically every month. This evaluation data is collected by taking logs on Fortimanager to see the SLA of the communication link for each branch. Several things are the evaluation points for SD-WAN implementation to ensure that the implementation is effective and efficient for Bank Mega:

Network Performance: Network evaluation includes latency, jitter, and data transfer rate to determine whether SD-WAN improves network performance.

Network Availability: Evaluation of network

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availability includes the ability of SD-WAN to maintain network connections and continue branch operations even if there is a failure on one of the networks links.

Ease of device management: This evaluation ensures that SD-WAN makes it easier to configure branch communication networks.

Cost: This evaluation calculates the efficiency gained from implementing SD-WAN. By changing one of the MPLS links to the Internet. This cost calculation includes the costs of hardware and communication links.

4. RESULTS AND DISCUSSION

A. Performance Analysis

At this stage, an analysis will be carried out on the implementation of SD-WAN in all Bank Mega branches. The analysis will focus on network performance, security and cost efficiency link communications generated by SD-WAN implementation. The aim of this analysis is to measure the extent to which SD-WAN provides benefits in terms of better network performance, improved network security and cost savings link communication.

Implementing SD-WAN can make performance more effective, and performance becomes more increasing. By implementing this technology, branch network operations become more effective and efficient in terms of time. SD-WAN makes it easier for Bank Mega's network team and monitoring team to manage and monitor each branch network. The following are the results of implementing performance analysis of SD-WAN implementation.

1. Centralized Management

Implementing SD-WAN will make device management more effective. All devices are centralized to one Fortimanager application. So, the configuration becomes very effective for all implemented branches (Mora-Huiracocha et al., 2019).

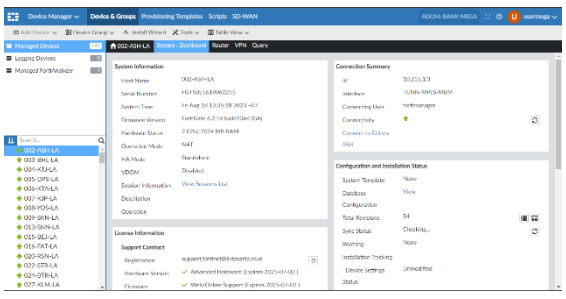

Figure 5. Display of Dashboard Fortimanager Bank Mega

Furthermore, an example of a comparison of the time required to configure all Bank Mega branches before using SD-WAN and after implementing SD-WAN in all Bank Mega branches can be seen in the table below.

Table 2. Comparison of configuration times before and after SD-WAN

Task	Before SD-WAN		After SD-WAN	
	Activity	Time (minutes)	Activity	Time (minutes)
Add new routing with Destination IP 192.168.1.0/24 to Data Center for 380 Branch	Remote to Branch Router via SSH	1	Remote to Fortimanager via Web Browser	1
	Add configuration to Branch Router ! ip route 192.168.1.0 255.255.255.0 nexthop 100.100.100.1 !	1	Create Template policy add route 192.168.1.0/24 to next hop IP Tunnel Data Center 100.100.100.1	1
	Save Configuration ! write memory !	1	Apply policy to all Branch Fortigate	2
	Repeat the configuration to all branch router.	1140	All configuration successful applied	10
	Total time in Minute	1143	Total time in Minute	14

In Table 2 you can see a very significant comparison in configuring network branch. Before SD-WAN it took 1143 minutes and after implementing SD-WAN it only took 14 minutes. The following is what appears when adding configuration to the side Fortimanager.

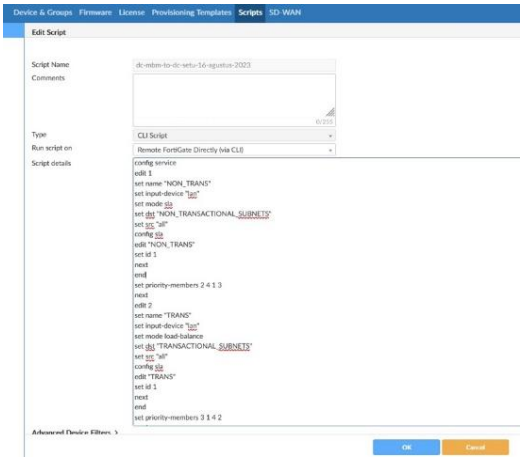

Figure 6. Script configuration in Fortimanager

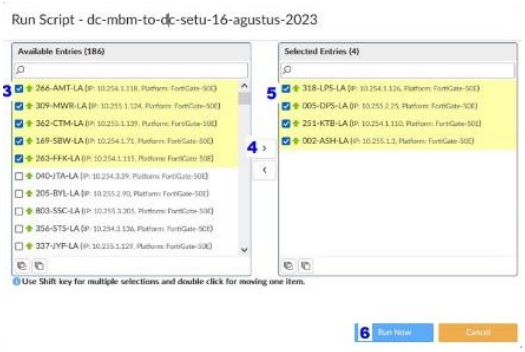

Figure 7. Script executed on each branch device.

As shown in Figure 6 and 7, Fortimanager add configuration to each targeted branch. Some

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Advantages of using Fortimanager SD-WAN configuration push includes configuration consistency across the network, ease of management from one point, and time efficiency in implementing network changes.

2. Quality Link Communication

SD-WAN devices can automatically determine the communication link used based on the link quality of the link (Radcliffe et al., 2019). Quality link can be seen from:

1. Latency Threshold
2. Jitter Threshold
3. Packet Loss Threshold

The following is the configuration on the SD-WAN Device to determine the SLA link used:

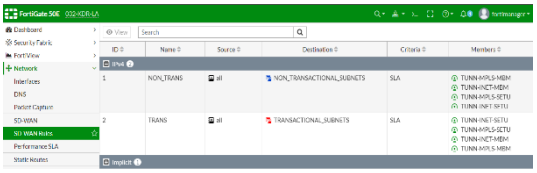

Figure 8. Configuration for determining network priority

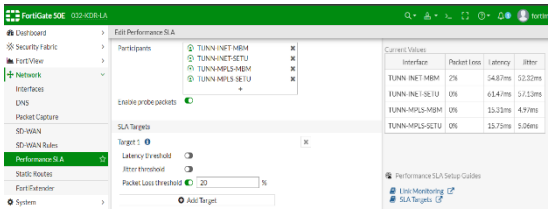

Figure 9. Configuration to determinethreshold Packet Loss

The pictures above explain the configuration of each branch to determine the priority of the communication network used. Figures 8 and 9 explain the MPLS Network configuration which the main priority backup link is using the Internet network. With Service Level Agreement (SLA) criteria Packet Loss no more than 20%. If one of the networks has Packet Loss on threshold then it will automatically move to the network backup.

3. Bandwidth Optimal

Bandwidth use becomes more effective because SD-WAN can use both existing communication links, MPLS and the Internet, effectively (Qin, 2022). SD-WAN configures to utilize the two links. The distribution of traffic for each link is determined by the destination IP segmentation configured in the policy.

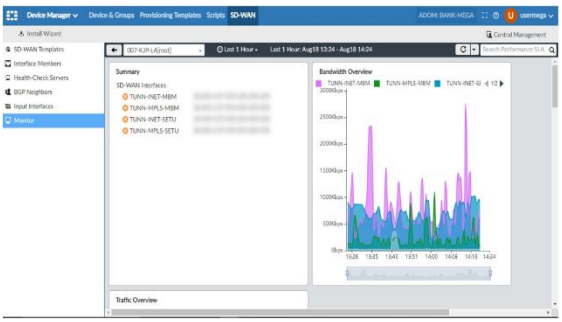

Figure 10. Fortigate Division BranchTraffic Internet and MPLS

The Figure 10 provides information regarding the distribution configuration traffic both communication links are running. Tunnel Internet and Tunnel MPLS has traffic so that both links are effectively used to increase usage bandwidth optimally.

4. Branch Network Security Analysis

Implementing SD-WAN technology will increase network security at every Bank Mega branch (Bustamante & Avila-Pesantez, 2021). Several technologies are implemented to improve branch network security:

1. Data Encryption: SD-WAN Fortigate provides strong data encryption to protect data transmitted over the network. Encryption protocols such as IPsec or SSL/TLS can be used to ensure the confidentiality and integrity of data when moving between different network locations.

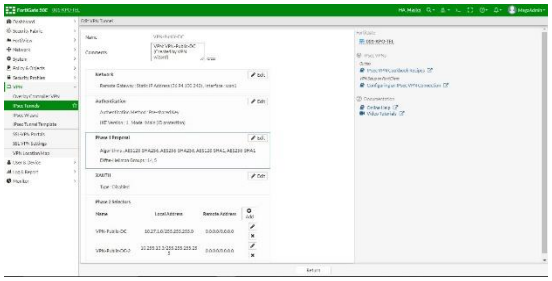

Figure 11. IPSEC Configuration

The configuration IPsec Tunnel on the device Fortigate at every Bank Mega branch is shown in Figure 11. By carrying out this implementation, data security from each branch is increased. IPSec tunnel used to secure traffic sent over SD-WAN lines between various locations or branches.

2. Filtering Traffic: SD-WAN Fortigate impose any restrictions traffic at the permit and deny. Only traffic which is permitted in policy who can enter and leave Bank Mega branches.

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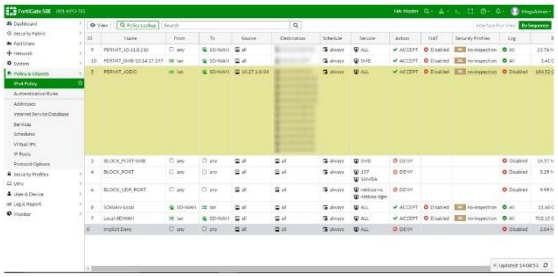

Figure 12. Configuration Firewall

The Figure 12 shows the configuration Firewall based on the source and destination of the data. An example of a branch configuration with the branch IP segment is permitted for communication to the server in the Bank Mega data center. As shown in Figure 13-15, Fortigate offers advanced security monitoring capabilities, including live network traffic monitoring real-time, security threat monitoring, and detailed traffic analysis. This enables early identification of security threats and rapid action to address security issues that may arise.

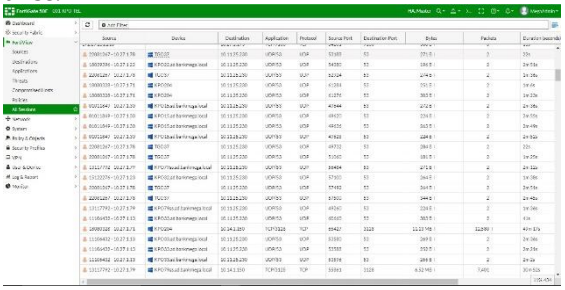

Figure 13. Monitoring All Traffic

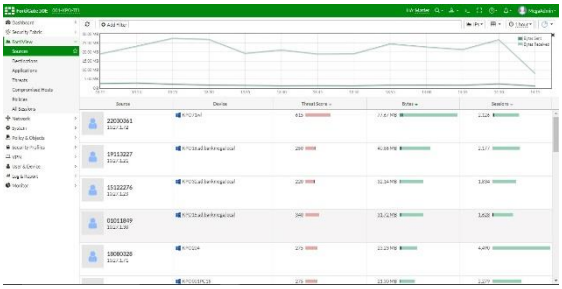

Figure 14. Monitoring based on data sources

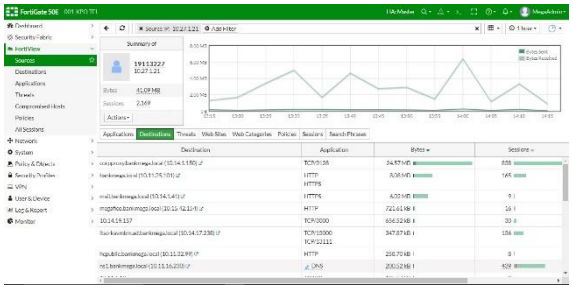

Figure 15. Monitoring based on data objectives

With those monitoring, it will increase visibility network in each branch. So that Bank Mega can carry out further analysis of any traffic anomaly that could potentially lead to attacks on that branch.

4. Cost Efficiency Analysis Link Communication

Implementing SD-WAN provides efficiency in Operational Expenditure (OPEX) costs for paying communication link costs for all Bank Mega branches. Estimated cost reduction reaches 30% of communication link costs before using SD-WAN (Andromeda & Gunawan, 2020). Total efficiency with estimated calculations as follows for 380 Mega Bank branches.

Table 3. Costs of Existing Bank Mega Branch Communication Network

				Link 1 - MPLS		Link 2 - Metro E	
No	Branch Category	Bandwidth	Total Branch	Cost / Month	Total Cost	Cost / Month	Total / Cost
1	Sub-Branch Office	256 Kbps	320	3.000.000	960.000.000	2.700.000	864.000.000
2	Branch Office	512 Kbps	50	4.000.000	200.000.000	3.000.000	150.000.000
3	Regional Branch Office	1 Mbps	10	5.000.000	50.000.000	3.500.000	35.000.000
			380		1.210.000.000		1.049.000.000

Total Cost Per Month	2.259.000.000
Total Cost Per Year	27.108.000.000

Table 4. Bank Mega Branch Communication Network Costs with SD-WAN

				Link 1 - Internet + SDWAN		Link 2 - Metro E	
No	Branch Category	Bandwidth	Total	Cost / Month	Total Cost	Cost / Month	Total / Cost
1	Sub-Branch Office	2 Mbps	320	1.500.000	480.000.000	2.700.000	864.000.000
2	Branch Office	2 Mbps	50	1.500.000	75.000.000	3.000.000	150.000.000
3	Regional Branch Office	2 Mbps	10	1.500.000	15.000.000	3.500.000	35.000.000
			380		570.000.000		1.049.000.000

Total Cost Per Month	1.619.000.000
Total Cost Per Year	19.428.000.000
Cost Efficiency in a Year	7.680.000.000
Percentage Efficiency in a Year	28%

The Table 3 and 4 show a comparison of network communication costs before implementing SD-WAN and after implementing it. By changing the Multi Protocol Label Switching (MPLS) communication network to Internet Link and adding SD-WAN devices, the efficiency obtained is up to 28% or the equivalent of Rp. 7,680,000,000 in one year.

5. CONCLUSIONS

In this research, an analysis of the effect of implementing SD-WAN technology on network performance, network security and cost efficiency has been carried out link Mega Bank communications. Based on the findings obtained from this research, the following can be concluded:

From the results of the analysis carried out, it appears that the implementation of SD-WAN technology at Bank Mega has a positive impact on network performance. This technology enables data traffic optimization, increased network availability, and more effective management of data traffic. Application performance and network services appear to be more consistent and responsive after SD-WAN implementation.

In terms of network security, SD-WAN technology has brought improvements by providing more

advanced security features, such as data encryption and network segmentation. However, it is important to remember that these security benefits may vary depending on the exact configuration. Continuous evaluation is necessary to ensure that systems remain secure from evolving cyber threats.

This research shows that SD-WAN technology can help increase cost efficiency link communication by optimizing the use of available communication channels. Diverting traffic to more cost-effective and more stable routes can reduce costs and more stability can reduce operational costs in the long term. Communication network operational costs by replacing link MPLS make the internet overall more efficient by up to 30% every year. However, regular evaluation of the performance of the communication lines used is still necessary to ensure that cost benefits are maintained.

From the conclusions that have been made, suggestions that can be taken as a guide for Bank Mega in optimizing the use of SD-WAN technology are:

Optimizing SD-WAN configuration and management to ensure optimal network performance, Bank Mega should continue to monitor and manage SD-WAN configuration. This involves monitoring traffic, selecting appropriate communication channels, and adjusting security configurations according to evolving cyber threats.

Consider integration with additional security systems. Even though SD-WAN has security features, Bank Mega needs to consider integration with existing security systems to get a stronger layer of protection. This includes additional security software, security regulatory checks, and security training for staff.

Carry out regular evaluations of performance and cost efficiency. To ensure that the benefits of network performance and cost efficiency continue to be obtained, Bank Mega must carry out regular evaluations of network performance and cost efficiency of communication links. This will help in identifying changes that need to be made to maintain optimal levels of performance and efficiency.

Investing in developing Human Resources (HR) skills in facing technology that continues to develop and change, Bank Mega needs to invest in developing HR skills related to SD-WAN and cyber security. Training and certification will help improve the team's understanding and ability to manage this technology effectively.

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