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OPTIMIZATION PROBLEM OF COMPUTER NETWORK USING PPDIOO

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Abstract. *Quality of service in a company and institution is a point that must be taken into account to maintain core business. To support this, information and communication technology is used. This makes computer networks one of the indicators of success in supporting the quality of service so that existing computer networks must always be maintained and optimized. With a scalable network topology, measurable performance, and network monitoring devices, it is hoped that it can help maintain service quality. To optimize computer networks, the PPDIOO method from Cisco is used as a framework. The stages of this framework are Prepare, Plan, Design, Implement, Operate and Optimize. This work starts from the need for companies/institutions to use computer networks, considering existing networks, until produce an optimal network system. The results of this study indicate that the network system that is built can be measured and monitored, so the quality of computer network services can be maintained.*

Keywords: Computer network, PPDIOO, Network problem, Optimization, Network performance

1. **Introduction.** Customer trust for a company/institution is a very important factor [1]. To maintain customer trust, service quality in an agency must be properly maintained. In the era of Industry 4.0, information technology plays an important role in maintaining service quality. Data center was built to support it. Problems that occur in the data center would result in poor performance in service quality. And network infrastructure is a vital part of the data center.

In this case study, the data center network problem at the xyz agency will be analyzed. This xyz agency uses IT resources to support its core business. The system is connected to the public and all branch offices. All systems owned by xyz agency are placed in the data center. The xyz institution's problems are that Data Center Network (DCN) is no performance visibility, no documentation, no IP address management, poor user exeperience, no logs, and trouble shooting that exceeds service level tolerances. With existing DCN conditions, the ICT systems are not running optimally and institutions are unable to maintain customer trust.

Optimization of the existing network would take advantage of the PPDIOO method. The PPDIOO method is a methodology from Cisco that defines a continuous cycle of services required by computer networks [2]. In this method, the writer will perform Prepare, Plan, Design, Implement, Operate and Optimize. Through the PPDIOO method, the author will build a simple and scalable network topology, real-time data center network visibility, and Quality of Service (QoS) analysis to get a recommendation on whether the topology is suitable.

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Based on previous research, the PPDIOO method can produce an established system and solve existing problems and improve QoS including availability, latency, throughput. The paper is structured in the following way, first the introduction that has just been specified. The second section shows previous research and the state-of-the-art of the project. The third section emphasizes the research methodology used. The fourth section shows preliminary progress and discussion about the results. It culminates with the conclusions in the 5th section.

2. **Theory and Related Work.** To determine its condition, the Data Center Network (DCN) was evaluated from its performance. Basically, DCN performance is divided into 2, namely latency and bandwidth [3]. Bandwidth is the amount of data in bits that can be transmitted in the network within a certain period of time. Latency is how long it takes for data to arrive at the destination node. Latency is measured in units of time. A good latency is below 150 mS [4]. The combination of bandwidth and latency is used to determine network performance characteristics. The concept of Quality of Service (QoS) is used to maintain network performance. QoS refers to the network's ability to provide better services including latency and bandwidth [5]. DCN characteristic is determined by analyzing traffic, flow distribution, and failure. Firstly, in traffic analysis, it can be seen by how much data is going in and out of the data center. This is how the network utilization can be monitored. Secondly, in the flow distribution analysis, data flow can be monitored and measured. Lastly, to determine failure characteristics and tolerate failures found in the data center, failure logs are collected from the production data center. This document discusses a number of tests that can be used to describe network characteristics including latency, bandwidth and availability. It starts from defining, determining, and reporting test results [6].

Besides that, good DCN is scalable DCN. Scalable DCN is ability of a DCN, to handle a growing amount of work in a capable manner or its ability to be enlarged to accommodate that growth [7].

Network Monitoring System (NMS) is a system that continuously monitors network systems. NMS generates network performance reports including latency, availability, traffic and even anomalies within the network. By using NMS, we can perform network characterization [8].

Wireless network will be used to accomodate mobile network requirement. Good wireless networks have low latency and use energy efficiently [9,10].

PPDIOO is a method issued by Cisco to define a continuous cycle, phase by phase in order to design and implement a computer network [2]. The PPDIOO method starts from Prepare Phase which will identify requirements, Plan Phase to characterize it, Design Phase to create a system design, Implement Phase for design implementation, Operate Phase to run the system implemented, and Optimize Phase to evaluate the proposed system. In the Optimize Phase, if the proposed system resolves the problem, the cycle will stop. And if the proposed system has not solved the problem, the cycle will repeat with the Prepare Phase.

Among researches on network optimization using PPDIOO are Design and Validation of a Scheme of Infrastructure of Servers, under the PPDIOO Methodology, in the University Institution – ITSA [11], Designing Network Structure Data Center to Enhance Network Availability Using TIA-92 Standard and PPDIOO Life Cycle Approach method [12], and Optimization of a WiFi Wireless Network that Maximizes the Level of Satisfaction of Users and Allows the Use of New Technological Trends in Higher Education Institutions [13].

3. **Methology.** To solve the problems, the writer will use the PPDIOO method as shown in Figure 1.

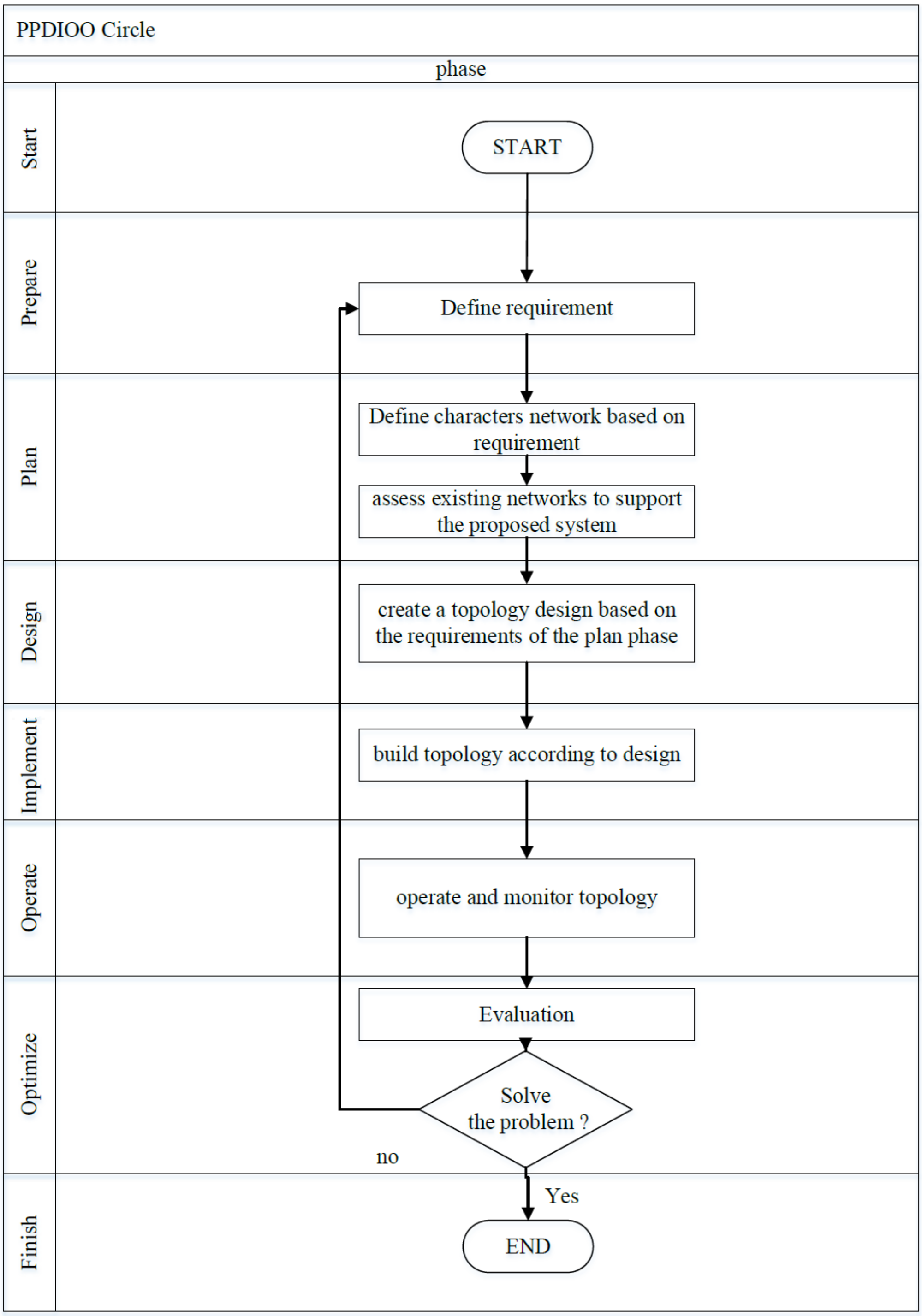


Figure 1. Cycle of PPDIOO

In the Prepare Phase, interviews from board level to staff level will be conducted to determine the requirements for the data center network that needs to be built.

In the Plan Phase, the necessary network characterization will be carried out by collecting interview data, analyzing the results and conducting an assessment of existing equipment. Network characterization includes business requirements, service level requirements, and infrastructure level requirements [14]. The result data from the Plan and Prepare Phases will be used to build DCN according to the requirements as in Table 1.

In the Design Phase, the author will propose the topology to be used for data center. In this topology, the authors would divide the network into 4 major groups, namely the server farm, CCTV, DMZ, and Campus LAN.

TABLE 1. Requirements of DCN

No	Requirements	Information
1	Provision of resources and services	DCN provides services to integrate all elements in the data center including network devices, network monitoring and analysis services.
2	Elasticity	DCN has to be flexible that any changes in the data center would not cause problems to the system.
3	Monitoring device	DCN has to have monitoring tools that allow DC operators to track the use of resources and services performance.
4	Accountability and service management	DCN has to be scalable and monitored to support services.

In the Implement Phase, the topology designed in the Design Phase would be built until the network is ready operation.

In the Operate Phase, all divisions use the network for daily operations as usual, such as accessing the Internet and accessing operational application systems. In addition to using the network, IT division, as a network provider, would also maintain network performance which includes throughput, latency, bandwidth and traffic, detecting errors such as connection loss and congestion.

The Optimize Phase evaluates the system being built. So it is described in the results and analysis chapter.

4. Results and Analysis.

4.1. Prepare. The results are as in Table 2.

TABLE 2. Results of the survey in Prepare Phase

No	User	Experience
1	Main officer	90% are dissatisfied with network services.
		100% of users feel that computer networks are very helpful in carrying out their tasks.
		The average official uses 11 online applications for business processes.
		95% of officials use apps to help make decisions.
		93% of officials implement an application system at the institution's data center.
		100% of officials use computer networks for daily work.
		The average official tolerates network downtime of no more than 5 minutes a day.
2	ICT division	The ICT division handles 52 applications on a national scale.
		The ICT division does not yet have visibility on the data center network.
		The ICT division uses manage services to maintain the network.
		The bandwidth used varies from 1 to 400 Mbps.
		Data center networks are not measurable and scalable.
3	Staff	93% feel less satisfied with network services.
		96% feel the network is very helpful in job assignments.
		The average staff uses 9 applications in their work.
		94% of staff feel that applications are very helpful in carrying out their duties.
		99% of staff use the network for daily work.
		The average staff tolerates network downtime of no more than 5 minutes a day.

4.2. **Plan.** The results are that service level must be maintained at 99.5%, networks must be monitorable, recordable and scalable, able to accommodate system application changes, and the last maximum latency of 15 mS.

The results of the existing network assessment are as in Table 3 and the addition of the equipment as in Table 4.

Table 3. Results of the existing network assessment

No	Device name	Brand/Type	Information
1	Core switch	Juniper/EX8200	End of Life (EOL) Devices on 1-Jul-2017 and End of Support (EOS) on 1-Jan-2022 Does not have a valid support contract
2	Distribution switch	Juniper/EX4200	End of Life (EOL) Devices on 1-Feb-2019 and End of Support (EOS) on 30-Jun-2024 Does not have a valid support contract
3	Access switch	Juniper/EX3200	End of Life (EOL) Devices on 1-Feb-2019 and End of Support (EOS) on 30-Jun-2024 Does not have a valid support contract
4	Access switch	EdgeCore/ES4524M-PoE	End of Life (EOL) Devices as of April 1-2014 Does not have a valid support contract
5	Router	Juniper/M10i	End of Life (EOL) Devices on 1-Nov-2015 and End of Support (EOS) on 1-May-2021 Does not have a valid support contract
6	Wireless	Ruckus/ZD300 & ZF7962	The device is no longer in use
7	Firewall	Juniper/SRX3400	End of Life (EOL) Devices on 1-Jun-2017 and End of Support (EOS) on 1-May-2021 Does not have a valid support contract Does not have a valid security subscription
8	Firewall	Juniper/SRX650	End of Life (EOL) Devices on 1-Nov-2015 and End of Support (EOS) on 1-Dec-2021 Does not have a valid support contract Does not have a valid security subscription
9	Firewall	Juniper/SRX240	End of Life (EOL) Devices on 1-Jun-2017 and End of Support (EOS) on 1-May-2021 Does not have a valid support contract Does not have a valid security subscription

The results of the operational network assessment are there is no network monitoring system yet so availability, utilization and latency are not measurable, there is no historical record, no network visibility, here is no network documentation that matches the situation in the field.

4.3. **Design.** The topology design is as Figure 2.

4.4. **Implement.** The following steps are mapping every IP addresses in the system, mapping traffic of existing applications, pre-configuration device, mounting data center devices, cable installation, power on test, connection test according to the traffic per application until connection comply. Next step is migration applications test until the network complies with the applications. after successful migration applications, then proceed to Operate Phase.

Table 4. Addition of new equipment

No	Device name	Brand/Type	Information
1	Core Switch	- 4 Cisco 3850-24S - 2 Cisco 3850-48T	6 switches configured to be a core switch.
2	TOR Switch	- 4 Cisco 3650-48	Switchs are used to connect servers on a rack server to the data center network.
3	Router	- 1 Cisco 4400	Router is used to connect between systems in order to communicate with each other.
4	Access Switch	- 6 Cisco 3650-24	Switchs are used to provide network access on each floor of the building.
5	External Switch	- 1 Cisco 3650-24	Switch is used to connect direct to external network provider.
6	Access Point (AP)	- 42 units	Aps are used to provide wireless network.
7	Wireless Controller (WLC)	- 2 units	WLC is used to configure and control AP.
8	Server	- 1 unit	Server is used to hosting Network Monitoring System (NMS).
9	NMS	- 1 package	NMS is used to monitor and measure DCN performance.

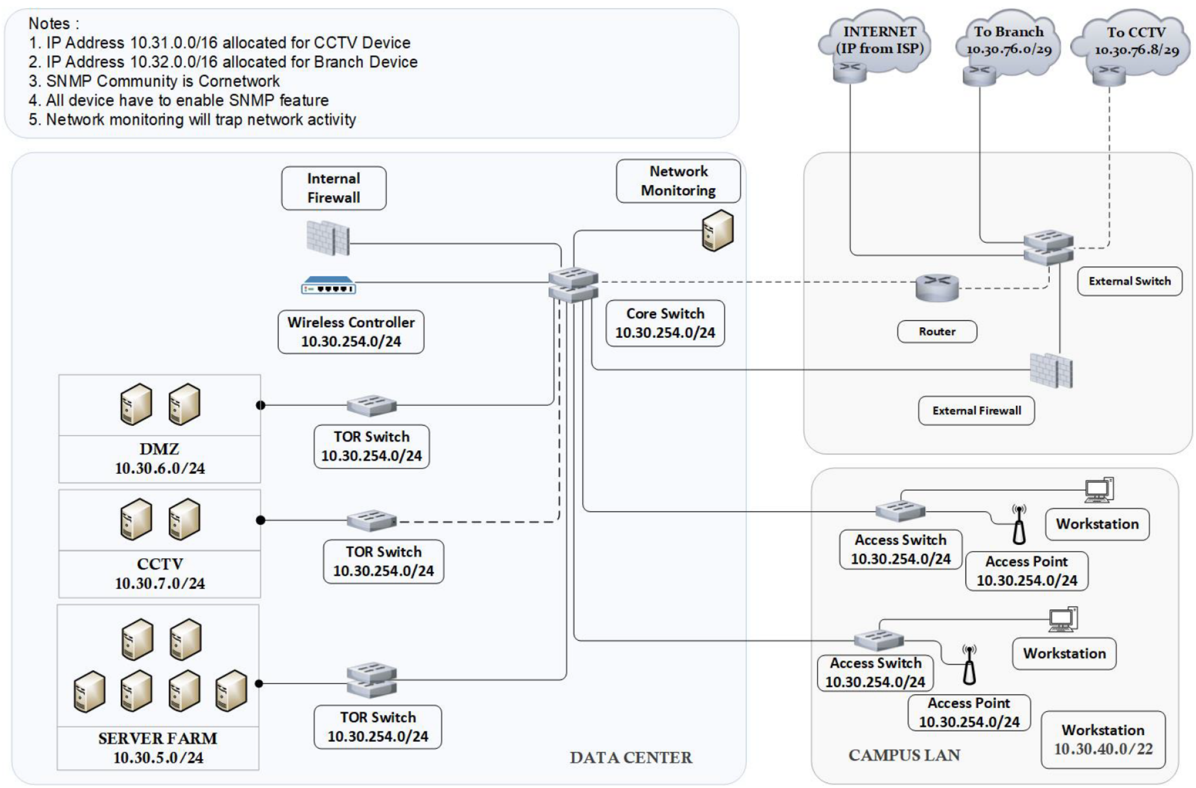
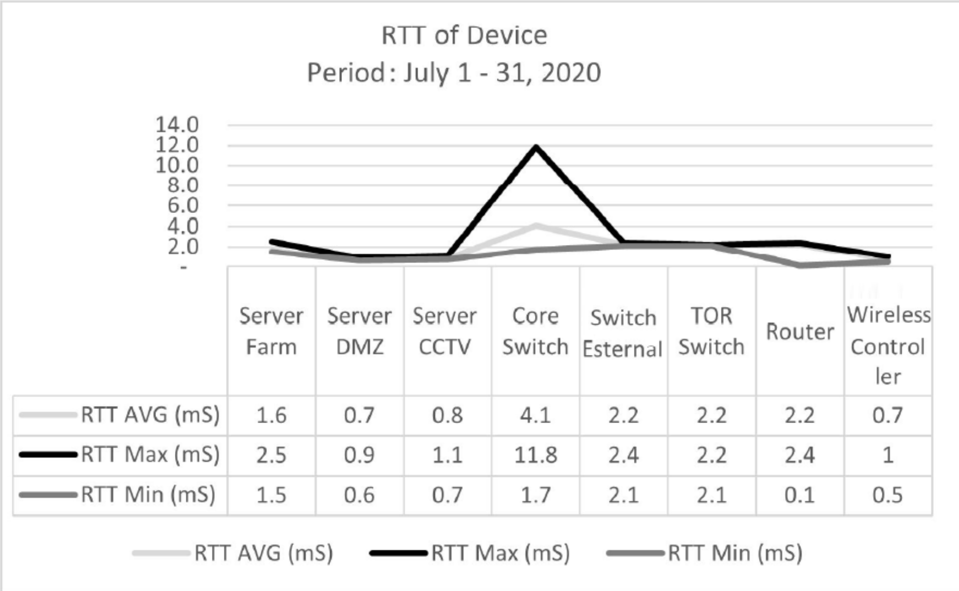


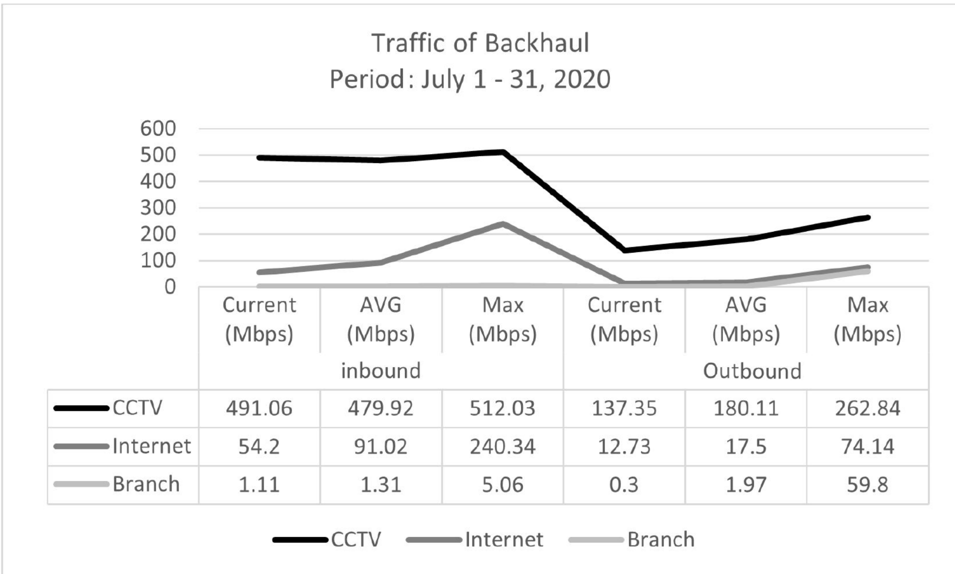
Figure 2. Topology built

4.5. **Operate.** In this phase, all users of IT system work as usual but are already using the new topology. The next step is to measure latency, traffic, and availability as shown in Figures 3 and 4. Measurements use network monitoring system (NMS) tools namely cacti, nagios and smokeping. Figure 3 shows RTT measurement results from 1 to 31 July 2020 on SF Server, DMZ Server, CCTV Server, Main Switch, External Switch, TOR Switch, Router, Wireless Controller. Based on the measurement result, it can be seen that all the



	Server Farm	Server DMZ	Server CCTV	Core Switch	Switch Esternal	TOR Switch	Router	Wireless Controller
RTT AVG (mS)	1.6	0.7	0.8	4.1	2.2	2.2	2.2	0.7
RTT Max (mS)	2.5	0.9	1.1	11.8	2.4	2.2	2.4	1
RTT Min (mS)	1.5	0.6	0.7	1.7	2.1	2.1	0.1	0.5

Figure 3. RTT of device



	inbound			Outbound		
	Current (Mbps)	AVG (Mbps)	Max (Mbps)	Current (Mbps)	AVG (Mbps)	Max (Mbps)
CCTV	491.06	479.92	512.03	137.35	180.11	262.84
Internet	54.2	91.02	240.34	12.73	17.5	74.14
Branch	1.11	1.31	5.06	0.3	1.97	59.8

Figure 4. Traffic of backhaul

largest RTT devices are 11.8 mS. In Figure 4, it is shown the results of measurement of traffic on the existing system which are CCTV, Internet, applications for branch. Measurements were made from 1 to July 31, 2020. The traffic measurement is divided into 2 groups, namely inbound traffic, which is incoming traffic and outbound traffic which is outgoing traffic from data center. From the monitoring results the availability of all network devices is 100%.

4.6. **Optimize.** In this phase an evaluation is carried out, by comparing the network requirements with the results of the Operate Phase and conducting a user experience survey of the proposed network system.

Table 5 is a comparison table between the requirements and the results of the proposed system.

Table 6 is a table of user experience with the results of the proposed system.

With the consideration of the evaluation, the proposed system can solve the problem so there is no need to do looping in the Prepare Phase.

Table 5. Comparison of system results and system requirements

No	The network required	The resulting network proposed
1	Service level must be maintained at 99.5%.	100% availability.
2	Networks must be monitorable and scalable.	Using the network monitoring system tool the network can be monitored and measured.
3	Able to accommodate changes to the application system.	With the new topology, any alterations and additions to the system will be well accommodated.
4	Maximum latency of 150 mS.	The maximum RTT in the measurement results is 2.4 mS.

Table 6. Proposed user experience systems

No	User experience
1	95% were satisfied with the network service.
2	94% felt the network was faster to access the Internet and systems than before.
3	93% correspondents have not experiencing problems in accessing the network.
4	94% correspondents felt the network is more stable than before.

5. **Conclusion.** The initial problem of the xzy agency is that it is not well documented; there is no monitoring on their performance, availability, and network utilization, no network history records, user difficulties in repairing the data center network if there is a problem.

After identification, the network requirements should be that service level must be maintained at 99.5%, the network must be monitored, recorded and scalable, able to accommodate system application changes, maximum latency of 150 mS.

The proposed network system that is proposed in the form of a topological repeat design using the PPDIOO method can run well and can solve problems faced by the xyz agency.

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