Unraveling Pakistan's Network Landscape - Legacy Structures vs. SDN Paradigms in the Internet Age in IoT Architecture

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Abstract- In this day and age of ever-expanding internet connectivity, human lives are completely reliant on the internet and the resources that it provides. Tasks that are performed on a daily basis are dependent, in some way or another, on the internet. Increasing the number of users leads to a growth in the amount of data, which in turn leads to an increase in the number of devices. Furthermore, according to human nature, the demand grows, which in turn leads to an increase in lust. It is necessary for humans to have the criteria of better and better being met. In this paper, a quick review of the network architectures is presented. These architectures are separated into two categories: the first is a legacy-based network architecture, and the second is an advanced and improved software-defined networking architecture. In order to answer the question of why legacy-based network architectures and infrastructures are still favored rather than SDN-based optimized network architectures, this paper is based on a survey that covers the demographic area of Pakistan as a majority. The survey was conducted in order to have an answer to the question. This study also discusses the literature that pertains to software-defined networks and the architecture of software-defined networks (SDN).

Index Terms- Legacy, Internet, SDN, Virtualization, AI-Router

I. Introduction

In the world where the internet is so rapidly increasing, now millions of peoples have changed the way they live and do the tasks. The ever-increasing need of fast internet have made it possible for the enthusiasts, network specialists or a person related to the internet, to be able to work on the betterment of the internet speed and as well as the ease of the complexities being faced by the IT industry and the users. The internet is revolutionizing at a greater rate every day, industry is changing ways by which the network structures are laid down and the ever-increasing need have already posed a lot of issues related to the maintenance of the data centers and the network configurations. In this new era of new technologies, the networking field now have a lot of success stories in implementing the new and fast advanced technologies. Talking about the legacy based traditional architecture the referral here is to the legacy/ traditional configurations of the networks all those messy data centers and dependency on different devices being used. Being clear here the conversation is all about the traditional routing and switching strategies and the way the devices were being configured by the network admins. Fig 1 shows the basic picture of the wired network architecture of a university which was designed and configured in the cisco packet tracer tool, note that this only is the core device setup. The traditional setup basically consists of the servers, firewalls, routers, Ulti-layer switches and many layer 2 switches being configured separately and if a change in network occurs every device needs to be updated almost every device which is a quite hard task for the network administrator. The router, switch, server, load balancer endpoints and many more of these devices have been overtime increasing their capabilities of handling the data from the different sources. [1] Routers are now called as ai based next generation routers, these routers are capable of taking their own decisions and they are more secure and reliable. [2] Routing have been quite intelligent lately, that it is now called as AI driven network routing, in these proposed architectures three layer logical functionality architectures are being researched and proposed upon which have shown pretty much the great results .The use of machine learning to make the routers intelligent, using hybrid ML techniques, RL algorithms, Q-learning algorithms and many more. Not only routers have become smart but on the switching level the things have been no more the traditional or legacy protocols based. Switches have now become Programmable switches which are using AI [3]. The traditional switches have a basic model of the control and data plane being on the same device but in these proposed architectures the switches are no more having a compact model but now the focus is on working to extract the relevant features from the switch, and in turn the basic thoughts are to make the switch programmable and more maintainable by separating the control and data plane. So overall the traditional networks are the networks using the network architectures and configuration protocols those are being used in the industry from so long and now these protocols and configurations or lay downs of the architectures have become so old that they cause problems in redundancy, maintenance, scalability and the providence of the fast and optimized network. The use of resources in these networks are also quite high. In order to configure a server a separate laptop or any connected device is used which causes the extra use of the resources and the extra efforts being used by the network administrator, also if an error occurs the IT admin have to go to every server to debug the issue that which issue is causing the error to be generated. Also in the legacy based networks the security is also the concern, because as the network is getting bigger and the scale of the devices to be handled and the log to be stored is increasing the usage of the power and the burden on the devices is increasing , which in turn can decrease the life span of the devices overall and the optimized performance of the network devices can't be achieved. But still now a days the advanced network architectures are not preferred and not used by most of the organizations and the enterprises. By the advanced architectures the mean is to refer to Dynamic configuration, Centralized Management, Quality of Service, Long Term Cost Saving, Ai- based networks, virtualization, software defined networks, API based networking, open flow network devices, smart devices, optimized green data centers, and many more.

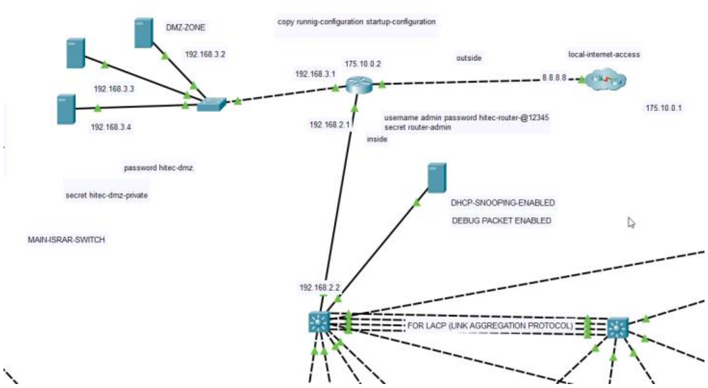

Figure 1 Wired Network Architecture

So what basically is the meaning of the legacy based architecture as the devices used in the advanced architectures are from the same families, like router is still a router, switch is still a switch, server is still a server, firewall is still a firewall, but now these are all having some super powers, the powers given to them by giving them the freedom from the old compact architecture restrictions, and making them smart enough to do the decisions on their own. With the power of Ai what network now a days is capable of doing will be the main discussion in this section of the article also discussing the main legacy-based network architectures/ infrastructures.

Therefore, the discourse may commence with the definition of "legacy," which essentially means that a contemporary network architecture is obsolete. In the contemporary era, network devices have undergone significant advancements in both hardware and software applications. However, despite this, industry-specific architectures continue to rely on outdated devices obtained from vendors, which are deemed unreliable. Furthermore, the devices utilized are not directly supplied by the companies. This action is taken to conserve both financial resources and legal documentation. Legacy-based network architectures are vendor-specific, and the majority of devices operate on hardware components. It is important to note that the definition of a legacy-based network may vary among different groups of individuals. The network architectures based on legacy technologies lack the necessary adaptability to integrate further advancements. Figure 2 illustrates the legacy-based network architecture that is being configured using conventional methods in order to attain internet availability functionality. The older devices are utilized, which has the disadvantage of utilizing obsolete protocols. Both the older and newer protocols have more stringent requirements for the devices to operate in an optimized manner. The utilization of outdated protocols renders older devices incapable of keeping pace with the internet patterns that are prevalent in the modern internet environment. As a result, data packet routing, transmission, and processing are not optimized to the desired degree. Therefore, legacy network architectures are primarily dependent on the devices, which are purpose-built and vendor-specific, comprised of highly integrated specialized forwarding chips, specific operating systems, and predefined features associated with each device [6]. This results in the constraint that if network policies are to be enforced on the device, then the individual configuring the device will be unable to utilize other vendor tools; therefore, they will be limited to utilizing devices that the vendors permit or that they have mentioned or developed. As a result of these factors, the delay for a new feature to be added to a particular vendor appliance can be lengthy at times; in certain cases, the infrastructure may continue to operate on obsolete or no longer-regarded standard protocols until the new release is available. Figure 2 [5] depicts the fundamental elements that comprise legacy-based network architectures. The fact that the network operating system, custom software, and network functionality are all contained in a single case demonstrates the reality of legacy-based infrastructures.

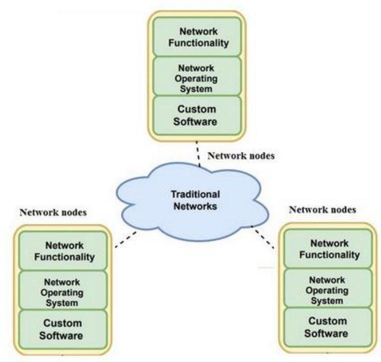

Figure 2 Legacy-Based Network Architecture

Advanced network architectures represent a paradigm shift in network management. They encompass various features such as programmable network devices, virtualization, the internet of things, improved performance, automation, enhanced security, real-time monitoring and control, increased control over the internet, simplified configuration processes, vendor independence, open flow, software defined networking, and software defined wide area networks. The hybrid implementation of various cutting-edge technologies has additionally yielded a network architecture that is optimized, programmable, and significantly more secure. With the advent of the internet of things, the majority of the applications that impact our daily lives are now IoT-based. These applications are technologically advanced, as they are also integrated with the SDN. IoT-based networks rely heavily on dynamic factors, such as resource limitations including battery capacity, processing power, and data storage capability. Consequently, the networks must essentially adapt to the specific demands of each user. Thus, success with regard to this facet of the internet of things can be attained by implementing APIs in software-defined networks; this is the primary factor that renders SDN a more appropriate networking architecture [7, 8].

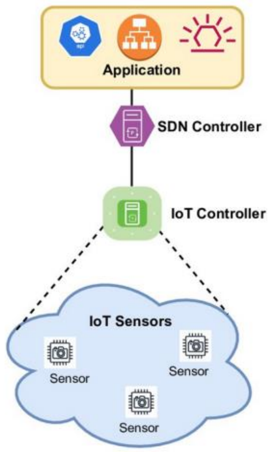

Figure 3 SDN IoT Architecture

II. Literature Review

It's This section will provide a comprehensive outline of the cutting-edge technologies in the field of networking and the ways in which artificial intelligence (AI) is impacting network architectures to enhance their intelligence. It will also discuss the progress made thus far in this regard and identify specific algorithms or techniques that have garnered attention. Martin Cosada, the progenitor of Software-Defined Networking (SDN), was once queried about its precise nature. He responded, "I am uncertain at this time due to the fact that its definition has evolved into something of an umbrella term, encompassing a multitude of software-based approaches to network management and manipulation." In the realm of networking, SDN is currently being implemented in three distinct ways: through Open Flow, the SDN API, and virtual machines (VMs), such as when constructing VXLAN tunnels. "In the SDN architecture, the control plane and data plane are decoupled; network intelligence and state are logically centralized; and the underlying network infrastructure is abstracted from the applications," according to the Open Network Foundation. [10] The concept of SDN is multifaceted and cannot be reduced to a singular entity due to the fact that its definition varies among individuals. By separating the control plane and data plane, software-defined networks have introduced flexibility to the networking field. As illustrated in Figure 4, the SDN architecture generally comprises three layers: the application layer/plane, the control layer/plane, and the data layer/plane, in that order. Additionally, it features three APIs: southbound, northbound, and east west [9].

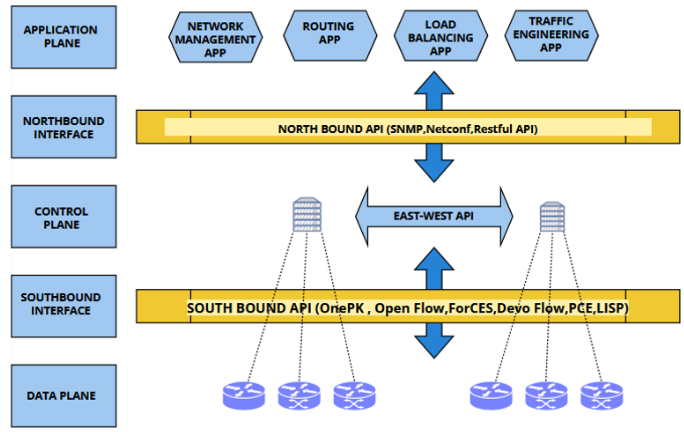

Figure 4 Control Layer Plane and Data Layer Plane

The forwarding plane, alternatively referred to as the carrier plane, is one of the three layers comprising the SDN architecture. Its primary function is to manage the data traffic generated by the forwarding plane in accordance with the configurations provided by the control plane. The operation of the control plane is imperative for the data plane to effectively execute its responsibilities. There are two distinct categories of switches in the data plane: physical and virtual. The open v switch, one of three implementations of a virtual switch in SDN, is the most well-known appellation because it operates on any operating system, including Linux, Windows, and others. Physical switches are the term used to refer to hardware switches. Two physical switches that are based on NetFPGA technology are Server Switches and Switchblade. Merchant switches that support SDN protocols have been developed by numerous networking hardware vendors, including Cisco, Juniper, Hewlett Packard Enterprise (HPE), Dell Networking, Aruba Networks (a Hewlett Packard Enterprise), Extreme Networks, MikroTik, Netgear, Ubiquiti Networks, Brocade (now a part of Broadcom), NEC, and HP. When discussing virtual switches, it is worth noting that nearly all switches possess the complete functionality and capability to configure SDN. However, this functionality is not present in physical switches. Notwithstanding this benefit, the physical switch remains functional due to its substantial data forwarding rate. The policies applied to the received data packets determine whether they are inspected, forwarded, or discarded by the control plane. The data plane and control plane communicate via the southbound F API.CONTROL PLANE SIZE: In both practice and theory, the control plane is referred to as the "brain" of software-defined networks. This is the most crucial of the three planes, as it facilitates network programming and enables dynamic resource utilization, thereby increasing the network's adaptability. The control plane primarily serves two purposes: one is to abstract network state information for the application plane, and the other is to convert application requirements into customized policies that are transmitted to forwarding devices. The control plane delivers the particular functionalities that are inherent in the network infrastructure, such as load balancing and routing. A multitude of controllers exist, including but not limited to POX [11], RYU [11], ONOS [12], Open Daylight [13], Floodlight [14], Beacon [15], Trema [15], NodeFlow [15], and Maestro. Controllers must be able to communicate via the following three interfaces: southbound interfaces, east/westbound interfaces, and northbound interfaces. The application plane, which is the highest level of an SDN-based architecture, houses applications designed for a variety of purposes, including network management, traffic engineering, security, routing, load balancing, QoS/QoE, and many others. These applications function by transmitting a command to the controller, which subsequently carries out the configuration of the connected system. Essentially, this is an interface or plane that oversees and manages the configuration, maintenance, and overall management of the SDN architecture. It focuses primarily on the administrative and operational aspects of the network, ensuring that all organizational requirements are met, the network effectively responds to changes and challenges, and it operates securely. Definition of Virtualization: the process by which computer resources are shared and abstracted away, giving the appearance of sole ownership to multiple parties [16]. The principle of virtualization also encompasses the reduction of network device expenses; rather than purchasing a server priced at 2.5 million Rs in Pakistan, it is more cost-effective to virtualize the server and utilize it within the network. This can be achieved through the implementation of multiple virtual machines and the installation of servers on the virtual machines.ML in SDN: Machine learning, which is a subset of artificial learning, is essentially the process by which a machine discovers patterns in new data and then predicts or makes decisions regarding them. Machine learning involves providing an algorithm with a dataset from which it learns. When the algorithm is presented with new data, it generates predictions about that data based on the knowledge it has gained from the training data. Therefore, the fundamental concept is to empower computers to recognize patterns and generate predictions and decisions by utilizing the knowledge gained from newly introduced data. SDN is comprised of a centralized controller that controls the network beneath it; this simplifies network management and control. A controller can imbue the network with intelligence through the implementation of machine learning techniques, which enable it to execute data analysis, optimize the network, and automate the provision of network services. In essence, machine learning enables the SDN controller to be intelligent enough to be automated and make decisions based on the knowledge gained from the datasets; therefore, the network's adaptability is the characteristic that renders it more redundant and optimized.

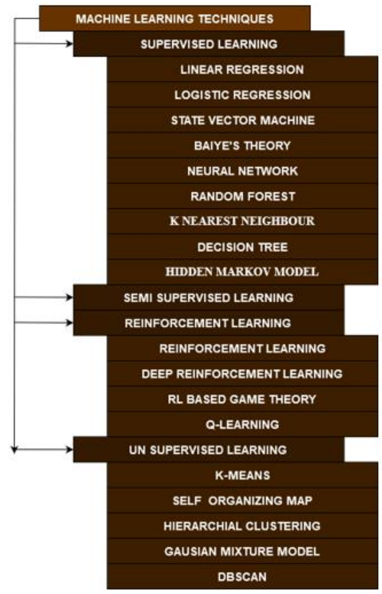

Figure 5 Machine Learning Technologies

The research environment in Pakistan has experienced substantial investigation into various technological fields, as demonstrated by the references to a series of studies provided herein. Bint-E-Asim et al. [17] conducted an investigation into the domain of online STEM education, with a specific emphasis on interactive learning facilitated by robotic kits. Prior to this, Hadi et al. [18] provided advice on freelancing strategies for beginners, illuminating successful methods for attaining success in this field. In their study, Lashari et al. [19] examined the educational effects of bespoke video game simulators in Pakistan, with a particular focus on the implementation of Universal Design for Learning. Danish et al. [20], in their transition to the Internet of Things (IoT), established a Smart Aquarium System that provided remote monitoring and control capabilities. Danish et al. [21], further investigating the influence of technology on education, conducted a comparative analysis of traditional approaches and augmented reality to determine their respective impacts on academic achievement in the classroom. Furthermore, by employing hybrid pedagogy and VARK analysis, the authors, in conjunction with other scholars [22], enhanced the efficacy of augmented reality-based e-learning applications in Pakistan. Furthermore, Danish et al. [23] directed their attention towards the assessment of the user experience of an augmented reality e-learning application, with a particular emphasis on the Work and Energy chapter [24].

III. Methodology

We initially conducted research on legacy-based network architectures, where we discovered that each individual has their own definition of the term. We then reviewed the literature regarding more advanced techniques developed in the modern era that aim to improve network architecture. While this field and these two subjects are sufficiently broad to warrant discussion, we opted to maintain clarity by administering a survey to network enthusiasts, the majority of whose responses pertained to the network industry and answered all of our inquiries. Pakistan, the focal point of our research, provided the majority of the responses to this survey. An inquiry emerges regarding the network's flexibility; to provide a concise response, let us delve into one of the definitions of SDN: when all control planes are hosted on a single controller, configuration of the etherwork is simplified. Changing configurations in legacy-based networks results in a highly compact architecture, which increases the risk of internet outages and requires changes to configuration protocols to be propagated to all routers simultaneously.

However, this is not the case with Software-Defined Networking (SDN), where the controller plane is tasked with communicating with and configuring devices lower in the hierarchy. As a result, the network design is adaptable. When a wire is disconnected in a traditional network, the configurations are lost. Therefore, when the device is reinstalled, it requires new configurations. However, this does not occur with centralized controllers; when a device is connected to the interface, the devices automatically retrieve the configurations, eliminating the requirement for the operator to reconfigure the devices. Having perused the entire article thus far, the reader should now possess a comprehensive understanding of the distinction between legacy-based network architectures and SDN software-defined networks, which are more advanced, technically sophisticated, and improved architectures. The thought occurred to us that if all technologies are advancing at such a rapid rate and producing flawless results, rendering resistance impossible, then nearly every organization should be adopting the new techniques. However, this did not appear to be the case. After conducting an investigation into various organizations and enterprises, we discovered that the majority of institutions, universities, and industries continue to utilize legacy-based network architectures. This raised concerns, so we aimed to address the matter through a survey that specifically targeted individuals associated with the network industry, network enthusiasts, and those interested in networks and related topics. An online survey was developed, comprising the following inquiries: the respondent's position within the IT industry, nationality, network infrastructure utilized by their organization, level of knowledge regarding software-defined networks, critical factors influencing the adoption of new network technologies, greatest obstacle to SDN implementation within their organizations, and anticipated benefits.

IV. RESULTS

Thus, following the completion of the survey, all the data were compiled and pie charts and graphs were produced in order to analyze the responses to the survey questions and provide answers to our inquiries. This section will provide an overview of each figure that represents the findings. The illustration presented in Figure 5 illustrates the proportion of responses obtained from specific regions and countries. The survey's primary focus was Pakistan, which increased the reliability of data collection through on-site visits to IT personnel and simplified the process in comparison to gathering data from the entire globe. Thus, the majority of the population (66.7%) originated from Pakistan.

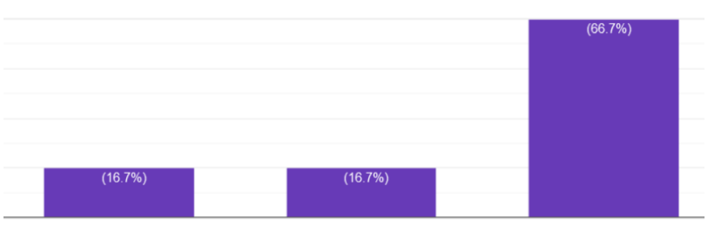

Figure 6 Distribution of Form Responders by Roles in the IT Field.

As shown in Fig.6, the form respondents held a variety of IT-related positions, with 33.3% concluding as IT staff, 33% as IT managers, 16.7% as network administrators, and the remaining respondents as SCs. This pie chart illustrates that the data being gathered originates from reliable sources and that every piece of information obtained from Pakistan was accurate.

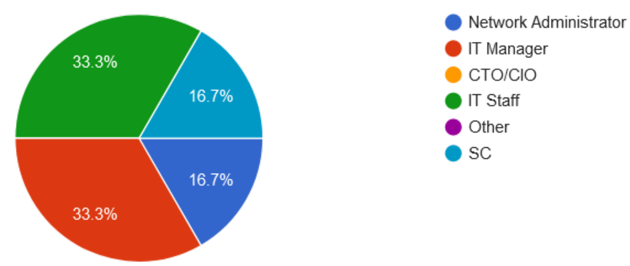

Figure 7 Knowledge Levels on Software Defined Networks (SDN) among Participants

Fig.7 presents the form-completer's level of knowledge regarding software-defined networks as the inquiry. Thus, in response, approximately fifty percent of individuals were informed and very acquainted. 33% of individuals were only moderately informed, while 16.7% were completely unaware of software-defined networks.

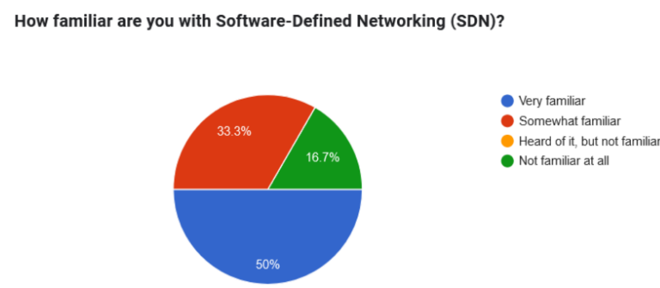

Figure 8 Key Implementation Factors Distribution for New Network

The query addressed in Figure 8 pertains to the factors that are deemed crucial during the implementation of the new network. Thus, the greater percentage, or 33%, was devoted to cost, 16.7% to security, 16.7% to ease of administration, 16.7% to scalability, and 16.7% to existing infrastructure compatibility.

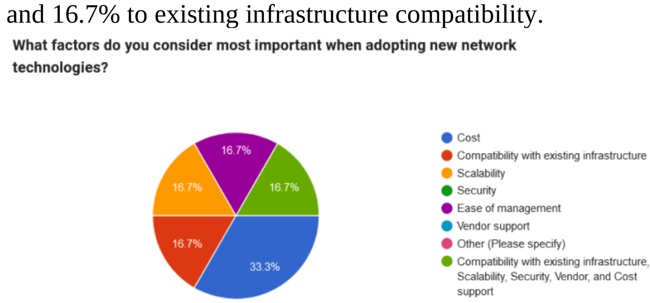

Figure 9 Reasons for Reluctance in Favoring SDN over Legacy-Based Network Architectures

As shown in Fig.9, when users were asked to select the reason they did not favor SDN over legacy-based network architectures that were less advantageous and less optimized, the majority of respondents (66.7%) cited the risk of disrupting existing services.

The high initial investment cost and dearth of expertise/training accounted for fifty percent.

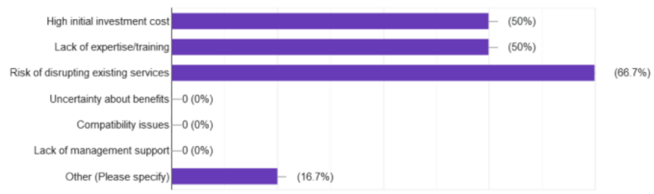

Figure 10 Barriers to SDN Adoption in the Network Industry

In conclusion, the network industry as a whole yielded the following final results: the majority of organizations are not migrating to SDN due to cost concerns and a lack of training; a sizeable proportion of individuals were apprehensive about the change because they were uncertain about the majority of the details; they are too accustomed to legacy-based network architectures to make the transition to a new, more complex system exceedingly challenging for them; and so on.

V. Conclusion

To the best of our knowledge, there has not been a survey carried out up until this point that primarily focused on Pakistan's network enterprises, universities, organizations, software houses, and network industries in order to collect information about these entities that continue to rely on legacy-based network architectures rather than the more advanced ones. As a result, we came to the conclusion that the SDN is not preferred because of the lack of expertise in training, the high initial investment costs, the risks of disrupting the existing services, the risks of management failure, and the less awareness to the technology. Legacy architectures are preferred because of the presence of existing skills, the simplicity of configuration, the distributed system, and the lower initial cost. Legacy networks offer more efficient working conditions and are simpler to troubleshoot. In legacy networks, the network administrator deals with a greater number of tasks, but in software-defined networking (SDN), you do not have the same degree of freedom.

VI. Future Work

In the future, a comparison between SDN and legacy-based network architecture will be necessary; for this, a large number of surveys should be conducted and data from all over the world should be gathered in order to answer the following questions: why is SDN still lagging behind, why are there cost concerns, and how can cost reduction strategies be determined? Further research is warranted regarding the application of machine learning to networks; at present, there is no dedicated model that functions exclusively for networks and can only function as a signature model. The implementation of software-defined networks in the actual world is necessary.

References

[1] Jiang, C., Ge, N., & Kuang, L. (2020). AI-enabled next-generation communication networks: Intelligent agent and AI router. IEEE Wireless Communications, 27(6), 129-133.

[2] Yao, H., Mai, T., Jiang, C., Kuang, L., & Guo, S. (2019). AI routers & network mind: A hybrid machine learning paradigm for packet routing. IEEE computational intelligence magazine, 14(4), 21-30.

[3] Xavier, B. M., Guimarães, R. S., Comarela, G., & Martinello, M. (2021, May). Programmable switches for in-networking classification. In IEEE INFOCOM 2021-IEEE Conference on Computer Communications (pp. 1-10). IEEE.

[4] Xiong, Z., & Zilberman, N. (2019, November). Do switches dream of machine learning? toward in-network classification. In Proceedings of the 18th ACM workshop on hot topics in networks (pp. 25-33).

[5] Siddiqui, S., Hameed, S., Shah, S. A., Ahmad, I., Aneiba, A., Draheim, D., & Dustdar, S. (2022). Towards Software-Defined Networking-based IoT Frameworks: A Systematic Literature Review, Taxonomy, Open Challenges and Prospects. IEEE Access.

[6] Hong, S., Xu, L., Wang, H., & Gu, G. (2015, February). Poisoning network visibility in software-defined networks: New attacks and countermeasures. In Ndss (Vol. 15, pp. 8-11).

[7] Huang, H., Zhu, J., & Zhang, L. (2014, June). An SDN_based management framework for IoT devices. In 25th IET Irish Signals & Systems Conference 2014 and 2014 China-Ireland International Conference on Information and Communications Technologies (ISSC 2014/CIICT 2014) (pp. 175-179). IET.

[8] Tadinada, V. R. (2014, August). Software defined networking: Redefining the future of internet in iot and cloud era. In 2014 International Conference on Future Internet of Things and Cloud (pp. 296-301). IEEE.

[9] Faezi, S., & Shirmarz, A. (2023). A Comprehensive Survey on Machine Learning using in Software Defined Networks (SDN). Human-Centric Intelligent Systems, 1-32

[10] Sezer, S., Scott-Hayward, S., Chouhan, P. K., Fraser, B., Lake, D., Finnegan, J., ... & Rao, N. (2013). Are we ready for SDN? Implementation challenges for software-defined networks. IEEE Communications magazine, 51(7), 36-43.

[11] Zhang, Y., & Chen, M. (2022). Performance evaluation of Software-Defined Network (SDN) controllers using Dijkstra's algorithm. Wireless Networks, 28(8), 3787-3800.

[12] Zhu, L., Karim, M. M., Sharif, K., Li, F., Du, X., & Guizani, M. (2019). SDN controllers: Benchmarking & performance evaluation. arXiv preprint arXiv:1902.04491.

[13] Ahmad, S., & Mir, A. H. (2021). Scalability, consistency, reliability and security in SDN controllers: a survey of diverse SDN controllers. Journal of Network and Systems Management, 29, 1-59.

[14] Mamushiane, L., Lysko, A., & Dlamini, S. (2018, April). A comparative evaluation of the performance of popular SDN controllers. In 2018 Wireless Days (WD) (pp. 54-59). IEEE.

[15] Paliwal, M., Shrimankar, D., & Tembhurne, O. (2018). Controllers in SDN: A review report. IEEE access, 6, 36256-36270.

[16] Wang, A., Iyer, M., Dutta, R., Rouskas, G. N., & Baldine, I. (2012). Network virtualization: Technologies, perspectives, and frontiers. Journal of Lightwave Technology, 31(4), 523-537.

[17] H. Bint-E-Asim et al., "Exploring Interactive STEM in Online Education through Robotic Kits for Playful Learning," vol. 19. [Online]. Available: http://xisdxjxsu.asia

[18] M. Hadi et al., "Exploring Freelancing as a Novice: Effective Strategies and Insights for Achieving Success." [Online]. Available: http://xisdxjxsu.asia

[19] T. Lashari et al., "Impact of custom-built video game simulators on learning in Pakistan using Universal Design for Learning." [Online]. Available: http://xisdxjxsu.asia

[20] A. S. Samad Danish et al., "Implementation of Smart Aquarium System Supporting Remote Monitoring and Controlling of Functions using Internet of Things," Journal of Multidisciplinary Approaches in Science (JMAS), 2019.

[21] A. S. Danish et al., "Comparative Study of Conventional Methods and Augmented Reality: Effects on Class Performance," Journal of Multidisciplinary Approaches in Science, vol. 7. [Online]. Available: https://www.researchgate.net/publication/337561169

[22] Ahmed, D., Dillshad, V., Danish, A. S., Jahangir, F., Kashif, H., & Shahbaz, T. (n.d.). Enhancing Home Automation through Brain-Computer Interface Technology. http://xisdxjxsu.asia

[23] Danish, A. S., Khan, Z., Jahangir, F., Malik, A., Tariq, W., Muhammad, A., & Khan, Y. (n.d.). Exploring the Effectiveness of Augmented Reality based

E-Learning Application on Learning Outcomes in Pakistan: A Study Utilizing VARK Analysis and Hybrid Pedagogy. http://xisdxjxsu.asia

[24] Danish, A. S., Malik, A., Lashari, T. A., Javed, M. A., Asim, H. B., Muhammad, A., & Khan, Y. (n.d.). Evaluating the User Experience of an Augmented Reality E-Learning Application for the Chapter on Work and Energy using the System Usability Scale. http://xisdxjxsu.asia

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