IoT Based Technique for Network Packet Analyzer

Nouh Alhindawi
Department of Software Engineering
Jadara University, Jordan
hindawi@jadara.edu.jo

Abstract: *Network demands are expanding dramatically, especially in educational sectors where systems are acting in a non-tradition network environment. Most of the services are published on the cloud so students can access teaching or learning materials directly; such demand is a heavy burden to systems administrators who needs to monitor critical educational services around the clock. However, such solutions need efforts, money, time, and space to be built; in this paper, the Internet of Things (IoT) is proposed as a small and cheap device that can be installed and configured to analyze packets locally for each service while analyzed logs can be synced simultaneously to have a complete view about systems behavior from any location for the education's system. Based on the results, the proposed approach showed a significant solution for the heavy demands on the educational system. Moreover, the results showed that the presented approach is more efficient when compared to the state of art packet analysis and monitoring approaches.*

Keywords: *Internet of things, packet analyzers, networks monitoring, cloud processing.*

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1. Introduction

The massive expansion of online services affects the behavior of the Local Area Network (LAN), especially when we are talking about educational institutes, where cloud and online services are a must with the growth of modern educational systems like Moodle, Blackboard, or even the Massive Open Online Courses (MOOCs) [17].

However, such newly born services are affecting the traditional behavior of the traditional local network instead of using the traditional Cisco 80/20 rule [22], which assumes that 80 percent or more of traffic should be local, while the other 20 percent or less should be forwarded to other network segments by the router. However, the modern educational systems are getting far away from the traditional Cisco rule with the need to migrate from only.

Local network concept to the new cloud concept is needed for the new educational systems with many students that the educational institutes offer as a service [18].

Such growth makes the local network behavior alien to traditional network administrators, especially when we are discussing the security of the local network and protecting educational institute assets. Therefore, packet analyzers should be used to analyze the behavior of the educational institute network to protect it from possible attacks.

Packet analyzers have been widely used to monitor the behavior of the network [6], giving network administrators an alarm for network misbehavior, network services, and more. However, network analyzers must be used in each network segment to collect the network behavior, meaning that each segment needs a dedicated machine to monitor the network. That machine needs power and space to be placed in small areas that do not offer such facilities.

Generally, numerous resources and researchers explained and clarified the concept of the Internet of Things (IoT) [3, 9, 12, 24]. As shown in Figure 1, based on the Gartner Hype Cycle (GHC), the IoT applications growth is so massive now that it can be used to solve many of the daily computer administration tasks. Gartner has released, shows IoT units installed based on category [7]. GHC is a graphical representation of the maturity, adoption, and business application of specific technologies. The Hype Cycle (HC) for the IoT is updated periodically and provides a snapshot of the most important IoT technologies and trends, as well as their current stage of development and adoption [5, 7].

The implementation of IoT in education interacting observing can carry out frequent aids. IoT strategies can display the presentation of education networks in real-time, adding insights into bandwidth operation, response times, and network obtainability. This data can help recognize blockages and steadfastness performance subjects beforehand they effect students and teachers. Furthermore, IoT can also increase the sanctuary of education networks by spotting and notifying administrators to possible security intimidations, such as unofficial access, malware contagions, and data breaches. The analysis of network traffic through IoT devices can afford insights into how students and teachers are using the system and which applications are intense the most bandwidth. Besides, IoT can also be used for extrapolative maintenance, serving administrators to proactively replace or repair network components before they fail, minimizing interruption and guaranteeing that students and teachers have admission to the network when they essential it.

Generally, IoT has the possible to revolutionize the monitoring of education networks, providing real-time understandings and serving to guarantee that these systems are always available, consistent, and protected. In more details, The IoT can also function as a packet analyzer by collecting and analyzing data packets transmitted between IoT devices in the network. IoT devices, such as sensors, cameras, and actuators, can generate large amounts of data that need to be analyzed in real-time. A packet analyzer can help to monitor and manage the flow of data within an IoT network, providing valuable information on network performance, data integrity, and security [5, 7, 8].

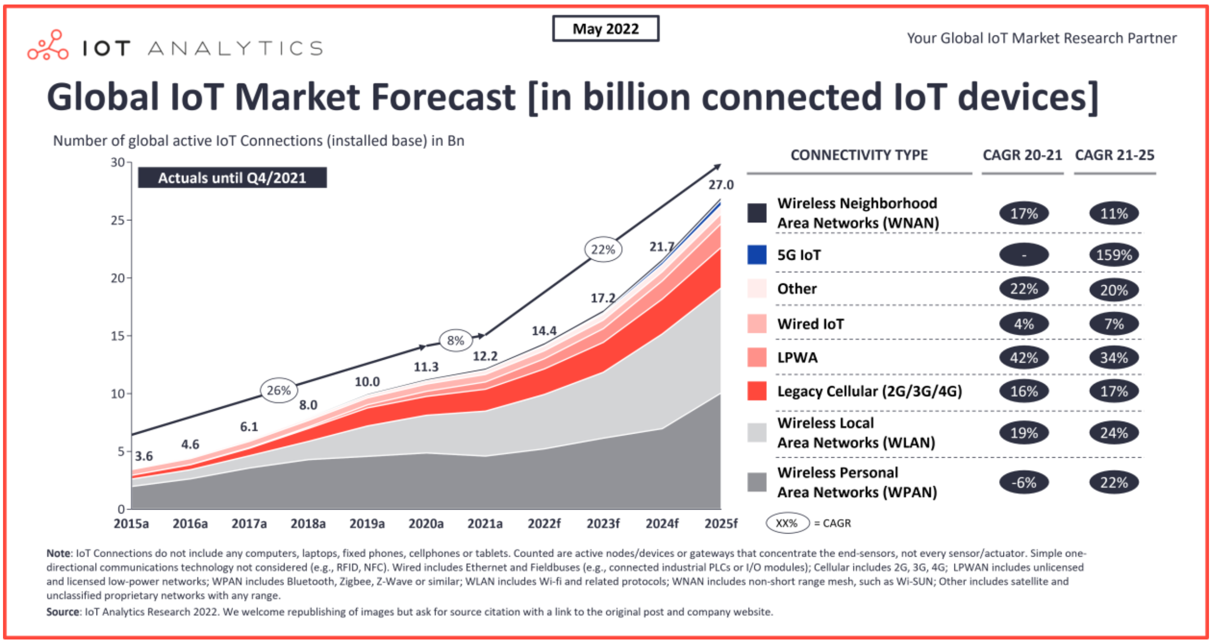

Figure 1. State of IoT 2022: Number of connected IoT devices growing 18% to 14.4 billion globally[1].

IoT is used as security equipment for analytics and security. GHC for the IoT in Figure 2 shows that using IoT as embedded software and security at the top of IoT applications [5]. As shown in the figure, The Gartner HC for the IoT, 2022 provides insights into the current state and future potential of various IoT technologies. It classifies numerous technologies and tendencies that are composed to have a important impact on the IoT market in the coming years. Some of the technologies underscored in the HC. As shown in the figure, The GHC for the IoT, 2020 delivers visions into the existing state and future possible of various IoT technologies. It categorizes several technologies and inclinations that are composed to take a important effect on the IoT marketplace in the future years.

The HC for the IoT delivers a complete view of the existing state of IoT technologies and their possible effect on dissimilar businesses. It helps organizations to recognize the trends and development patterns of these technologies and make informed decisions about investing in them. Furthermore, the HC provides an awareness into the encounters that administrations might face whereas accepting these technologies and the probable answers to overwhelmed them. This permits administrations to efficiently plan and implement their IoT plans and achieve their wanted consequences.

One of the main benefits of the HC is its capability to support administrations recognize the technologies that have touched the highest of their HC and are prepared for applied acceptance. This allows administrations to emphasis their efforts and resources on the technologies that are most related to their needs and are likely to offer the maximum aids. Additionally, the HC helps administrations to recognize the risk-reward relation of capitalizing in dissimilar IoT technologies and make knowledgeable choices about which technologies to accept and when.

The HC for the IoT is a valued instrument for administrations need to control the control of IoT technologies. By offering an up-to-date impression of the present state of these technologies and their possible effect, the HC helps organizations to make informed decisions about investing in IoT and achieve their desired outcomes.

[1]https://iot-analytics.com/number-connected-iot-devices/

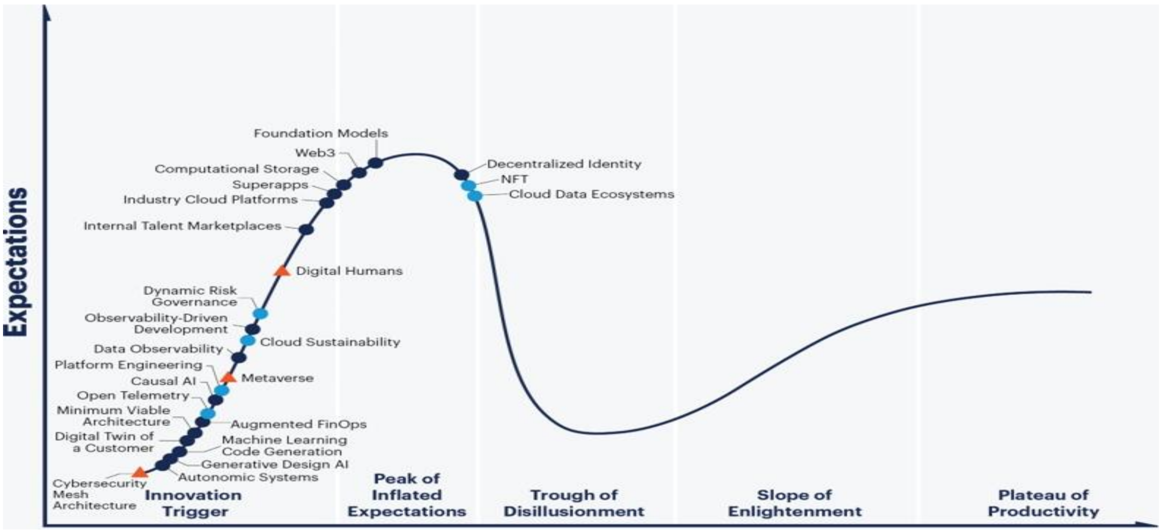

Figure 2. Hype cycle for the internet of things, 2022 (Gartner, 2022)[2].

2. Related Work

This section will cover six main bulletins:

1. COVID-19 and MOOC expansion.
2. Most common DMZ connectivity issues.
3. WSN as a packet analyzer.
4. MRTG as a packet analyzer.
5. The expansion of the IoT.

2.1. COVID-19 and MOOC Expansion

Student admission in MOOCs boards such as Coursera and Udemy has been extremely rising in the latest years. Nevertheless, since the start of the COVID-19 pandemic, the number of registered operators has increased particularly from industrialized countries [8].

The COVID-19 pandemic has had important influence on the teaching manufacturing, leading to extensive school ends and the move to distant learning. In reaction to this encounter, MOOCs have seen a important growth recently.

MOOCs are online courses that are available to everybody, wherever, and at any time, giving students with the suppleness to study at their own pace. The expansion of MOOCs throughout the COVID-19 pandemic has permitted educators to endure bringing teaching and training to students, even when in-person classes were not possible.

The development of MOOCs has also been determined by improvements in technology, which have made it simpler for instructors to carry online gratified and cooperate with students in real-time. With the use of video conferencing, online valuations, and other communicating tools, MOOCs have become an progressively real way to deliver education and training [8, 18].

In general, the COVID-19 pandemic has had a important impression on the teaching industry, leading to the fast growth of MOOCs as a way to continue transporting education and training to students. The development of MOOCs has been driven by advances in technology, providing students with the flexibility to learn at their own pace and from anywhere in the world. Such growth did not affect commercial MOOC services only. However, most universities with distance learning systems also needed a better IT infrastructure and better to connect to handle, monitor, and protect the extra traffic to the MOOC servers that were not before the pandemic. MOOC services and servers must be up 24/7 and can handle massive concurrent connections simultaneously [4].

2.2. Most Common DMZ Issues

DMZ stands for “Demilitarized Zone.” In computer networking, a DMZ is a physical or logical subnetwork that separates an internal network from the Internet. The purpose of a DMZ is to provide a secure and controlled access point for Internet traffic to the internal network. By placing critical resources such as servers and other important systems in a DMZ, network administrators can limit the risk of security breaches and protect sensitive information on the internal network.

Like most business facilities, many issues facing educational institutes' DMZ connectivity affect the service provided to students. Mazur *et al.* [13], explains the top 10 LAN issues, Domain Name System (DNS) problems, Application server reachability issues, and slow application performance are the most common, where users are facing a slow service or may even be unable to get it.

DNS using User Datagram Protocol (UDP) means that if there is some lack of connectivity with the DNS server will cause the client request to be lost and never be retransmitted. Alternatively, the wrong DNS is configured as the default DNS server for the client where the database for that DNS is not updated, causing

[2]https://www.gartner.com/en/articles/what-s-new-in-artificial-intelligence-from-the-2022-gartner-hype-cycle

the name resolution error.

Many reasons may cause application server reachability issues; it can be Virtual Local Area Network (VLAN) issues, Internet Protocol (IP) issues, or Wi-Fi issues.

The slow network may cause performance issues for the application server that can cause application hang or application misbehavior on the client side.

Such problems cannot be identified without using a packet analyzer to isolate the issue and try to predict the issue before it expands.

2.3. WSN as A Packet Analyzer

It has been hard for network administrators to predict or find network issues, especially within massive networks; getting professional packet analyzers requires a big budget and space to set up such analyzers. Meanwhile, WSN can be used as a packet analyzer to collect data and send them to the central server to be analyzed, as seen in Figure 3 [13, 15].

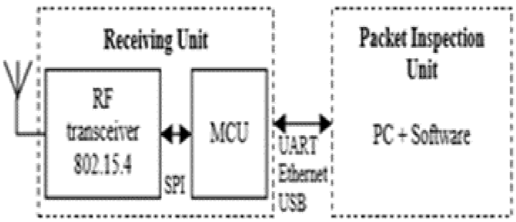

Figure 3. WSN packet analyzer.

While WSN can be used to collect the data locally and be analyzed, WSN can be part of the IoT node; IoT can then use the collected information about the network and share the network events from network segments to the cloud, where data can be analyzed. Usually, A Wireless Sensor Network (WSN) can function as a packet analyzer by gathering and examining data packets communicated among sensor nodes in the network. The packet analyzer can be applied as a software unit running on one or more nodes in the network or as a separate device connected to the network.

The packet analyzer's vital drive is to imprisonment, decode, and inspect the data packets conveyed between nodes in the network. This can provide valuable information on network performance, data integrity, and security. The packet analyzer can also identify and isolate network issues, such as mobbing, data crashes, and other errors.

In a WSN, the packet analyzer can screen data transmission rates, the types of data being transmitted, and the time mandatory for data to portable from one node to another. It can also analyze network traffic patterns and identify any blocks or areas of high mobbing.

Furthermore, the packet analyzer can also show a role in assuring the security of the WSN by monitoring for unauthorized fee attempts and other safety pressures. It can aware network managers to possible security breaches and assist in resolving these issues [15].

2.4. MRTG as A Packet Analyzer Tool

The Multi Router Traffic Grapher (MRTG) is a instrument to screen the traffic load on network links. MRTG makes Hyper Text Markup Language (HTML) pages covering Portable Network Graphics (PNG) images which deliver a LIVE visual representation of this traffic.

IoT has been used in many Real-time applications, as MRTG has been one of the intended applications as it can be deployed at any site for low-power applications. While WSN can be used to collect data using MRTG, IoT can collect and process data before sending them to the cloud to be processed and viewed for an easier way to read the real-time service status of the primary services for the university.

WSN can be used to gather data using tools like MRTG, which provides real-time network traffic monitoring and graphing. This permits network administrators to display the performance and status of the WSN and detect any issues that may arise [11].

In contrast, the IoT can gather and process data before transferring it to the cloud for further processing and analysis. The IoT devices can be prepared with influential processing competences that can achieve real- time data analysis, making it easier to view the real-time status of primary services for the university.

This permits administrations to have a more well-organized and real way of monitoring their network facilities and substructure, as they can view the real-time rank of their systems and obtain alerts if any subjects rise. The data composed by IoT devices can also be kept in the cloud for additional analysis and reporting, providing valued visions into the performance and fitness of the network [11, 14, 20].

2.5. The Expansion of the IoT

IoT has practiced important growth in latest years, as the number of associated devices has augmented melodramatically. IoT denotes to the connectivity of physical devices, vehicles, structures, and other items embedded with electronics, software, devices, and network connectivity, allowing them to gather and conversation data [19].

The growth of IoT has been determined by a number of influences, including the reduction in fee of sensors and other mechanisms, the growth in processing control and storage capacity of devices, and the development of cloud computing. This has allowed organizations and persons to connect a wider range of devices, from smart homes to manufacturing machinery, to the Internet [20, 26].

The expansion of the IoT has also carried about new chances and challenges. On one hand, IoT has the possible to transmute industries and recover people's lives by allowing new, more well-organized and automated ways of working. On the other hand, the growth of IoT has also increased security and privacy concerns, as the large number of connected devices has created new opportunities for cyber-attacks, the expansion of the IoT has been driven by advances in technology and declining costs, and has created new opportunities and challenges for organizations and individuals alike. As the number of connected devices continues to grow, it will be important to address security and privacy concerns in order to fully realize the benefits of the IoT [18, 25].

While WSN is used to send a triggered update about a specific condition, e.g., Temperature, Humidity, Gas, and more, IoT will use WSN to monitor without control; WSN will act as eyes, ears, and nose to the IoT, where the last will use WSN to monitor the environment and start to analyze.

Figure 4 shows the IoT technology roadmap from the year 2000 till 2020, where the business demand was the start for the expedited logistics till reaching the Software agents and advanced sensor fusion to meet the business and market needs in the future [1, 16, 21, 23, 27].

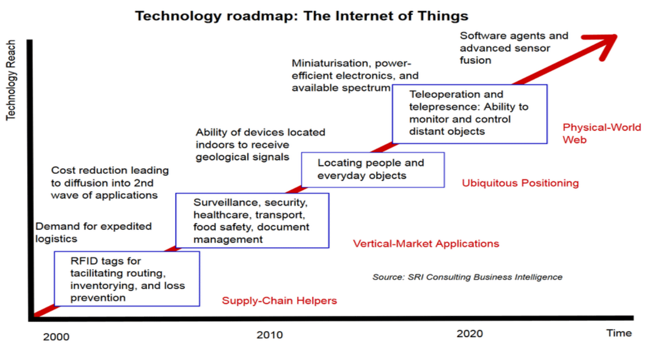

Figure 4. IoT roadmap [24].

3. IoT as A Packet Analyzer

The proposed methodology is divided into two parts or phases: the local segments and cloud processing.

3.1. Local Segments

In this phase of the IoT implementation, the focus is on creating local segments of connected devices that can collect and process data individually. By using tools such as Multi-Router MRTG, each node in the network will be able to collect data and process it locally, before sending it to the cloud for further analysis and processing.

The use of a real IP for connecting each node to the cloud will allow for efficient and reliable data transmission, ensuring that the information collected from each device is easily accessible and can be analyzed in real-time.

Having local segments of connected devices will provide several benefits. It will increase the speed and efficiency of data collection and processing, as each device will be able to process data locally before sending it to the cloud. It will also help to reduce the burden on the cloud and minimize the risk of data loss or delays in transmission.

The use of local segments in the IoT implementation will provide a more efficient and reliable way of collecting and processing data, and will help to ensure that the information gathered from the connected devices is easily accessible and can be analyzed in real-time [2, 23].

3.2. Cloud Processing Unit

Here, all local segments in this phase will be connected to remote centralized IoT MRTG to process all more extensively; this will give the administrators a complete view of the current network activities and any strange behavior within the segments, especially in case of service lack or if it is down.

The analyzed data can be used to predict the network behavior by a specific time within a year, month, week, or even by day; for example, when students have a final exam, study materials servers (e.g., E-Learning) will have the most hit by that time. Then systems administrators can take an earlier prediction to take further steps to support the expansion of the service demand before having an unwanted service lack.

Three services will be analyzed regarding related work; the first thing the system should log in to is the DNS, the second system to be analyzed is E-Learning, and the third system is Edugate.

The three systems that will be analyzed will be logged so that each system will have its own MRTG IoT; each system will send logs to the cloud, where another MRTG IoT node will display a whole image about the three systems so system administrators can quickly check the performance of the analyzed services.

Figure 5 shows the three services and how IoT will contact them and send the MRTG triggers directly to the cloud to be collected and analyzed by a centralized IoT MRTG node to view the system behavior fully.

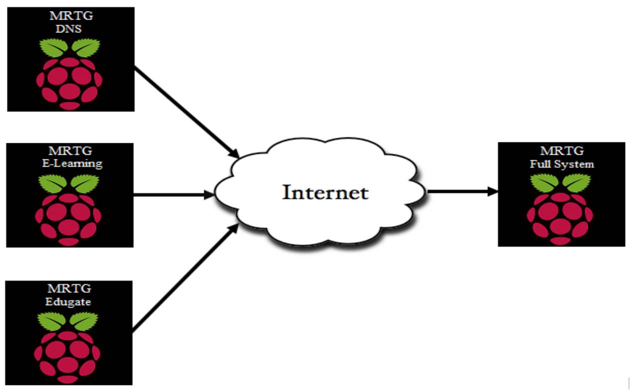

Figure 5. IoT full system overview.

4. Service Analysis and Discussion

As shown in Figure 6, there are for services, DNS, E-Learning, Edugate, and E-exam services, which will be analyzed with the same method.

The nslookup command will be used to communicate with the server and get connectivity results, 0 for no connectivity or one if connectivity is up.

```
Algorithm Service_Status (Z)

Y= Target Server
    X = Nslookup packet Y
        for all packets Xi do
            if Xi = 0
                Z= Service is done
            else Xi = 1
                Z = Service is up
            endif
        endfor
    return(Z)
```

Figure 6. Three services command.

The connectivity result will be sent to the local MRTG IoT node and will be displayed on the graph; Figure 7 shows an output result for the MRTG IoT node for Educate.

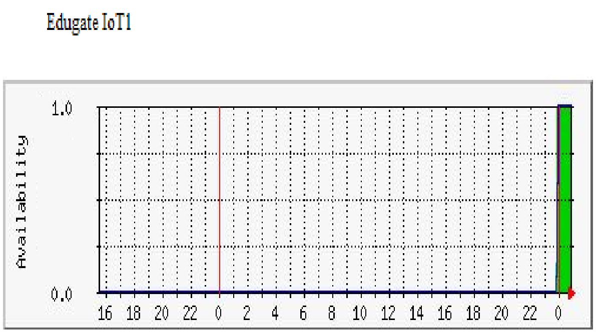

Figure 7. Output result for MRTG IoT node for Edugate.

Meanwhile, the results will be synced to the remote IoT MRTG to be viewed and analyzed by the administrators; Figure 8 shows a sample of the remote IoT analyzed services.

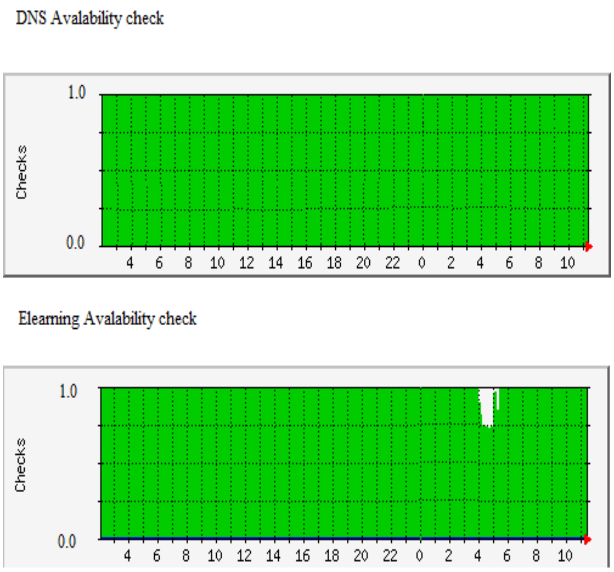

Figure 8. Sample for the remote IoT analyzed services.

The Table 1 shows the accumulative result for the services DNS, Edugate, and E-Learning; the service for the DNS where 100% up, for the Edugate service was 99.8% up, and for the learning was 99.8 up, and 100% uptime for the E-exam. The stability of the services gives the administrators a complete view of the behavior of the service.

Table 1. Cumulative results.

Service	UP Time
Edugate	99.8%
E-Learning	99.9%
DNS	100%
Eexam	100%

The results show a stable educational system with a high availability of teaching services even within peak times.

In conclusion, the IoT based technique for network packet analysis is considered as a significant tool for learning facilities. By gathering, processing, and analyzing data packets communicated between IoT devices in the grid, organizations can take valuable visions into the effectiveness and safety of their network substructure.

The IoT based network packet analyzer can offer real-time watching of network traffic, data transmission rates, and network performance, helping to recognize any issues and ensure that data is transmitted efficiently and steadily. This is especially significant in educational services, where dependable and secure communication is essential for providing quality education and services to students.

Moreover, the use of IoT based techniques in network packet analysis can offer educational services with a more effective and effective way of monitoring their network infrastructure, making it easier to classify and resolve any issues that may arise. This can eventually lead to enhanced network performance, augmented efficiency, and an improved general practice for students and staff.

5. Conclusions

In this paper, an IoT-based solution is used as a small, low-cost device instead of high-cost equipment to collect and analyze data from services that should be up to serve the students and lecturers that mostly use services from remote locations.

While current methods try to solve service availability, monitoring needs time and money, IoT has local IoT nodes for a small cost. Each node will monitor a service that can be later analyzed for another administration process (if needed). Educational services were up by more than 99.8% of service uptime, which indicates systems behavior. Based on the results of the experiment, the presented technique got an excellent rank compared with the state of art techniques regarding packet analysis and monitoring. Moreover, the paper shows that using IoT as base technique for network packet analysis is a valuable tool for educational service by providing real-time monitoring and analysis of network performance and security, leading to improved efficiency and a better overall experience for students and staff.

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Nouh Alhindawi is an Associate Professor in Software Engineering and Computer Science. Currently, he serves as the Assistant of the President of Jadara University for Digital and Electronic Transformation and E-Learning. Prior to this, he held the position of Director of Information Technology and Electronic Transformation Directorate at the Ministry of Higher Education and Scientific Research (MoHESR) from 2018 to 2022. He was also the head of the National Open Education Resource Center in Jordan, a newly established umbrella organization for education resources in the Jordan. Dr. Alhindawi holds a PhD in Computer Science/Software Engineering from Kent State University in the United States, as well as a Master's degree from Al-Balqa Applied University and a Bachelor's degree from Yarmouk University in Jordan. His research interests encompass a range of topics including Software Engineering, Data Mining, Machine Learning, Information Retrieval, and E-Learning. He has published several papers in international conferences and journals, and has been an active participant in various projects and initiatives aimed at advancing the field of software engineering and e-learning. Throughout his career, Dr. Alhindawi has demonstrated expertise in leading and managing technology initiatives. He has a proven track record of successfully implementing projects in the fields of information technology and e-learning, and is highly regarded for his contributions to the field. As the Assistant of the President of Jadara University for Digital and Electronic Transformation & E-Learning, he is responsible for driving the university's digital transformation efforts and ensuring that it stays at the forefront of innovation in e-learning. In recognition of his achievements, Dr. Alhindawi has received several awards and recognition from organizations and institutions.