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The Experimental Solution to The Problem of Communication Infrastructure in The Most Deadly Natural Disaster:(230206:0427) of Modern History

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ABSTRACT At 4:17 AM on February 6, 2023, a 7.8 magnitude earthquake struck, bringing devastating consequences to many cities in Turkey. This earthquake has been recorded as one of the biggest disasters of the 21st century and was felt in 10 provinces. The event underscored the importance of deployable communication infrastructure. This project focuses on how communication infrastructure can be quickly established in any emergency situation. The primary objective of the project is to ensure that people can communicate with each other during emergencies such as earthquakes.

In this project, three out of the ten affected cities have been selected as examples: Urfa, Hatay, and Adana. Additionally, a city that would not be affected by the earthquake was chosen to host the servers. Konya, known for having the lowest earthquake risk, was selected for this purpose. Drones play a critical role in providing network infrastructure. The aim of using drones in this project is to avoid the chaos caused by debris from collapsed buildings. Mobile access points were established using drones in the earthquake-affected cities, allowing communication even for those trapped under rubble. The infrastructure aims to save lives and deliver aid to those in need.

To simulate the network infrastructure, plan the necessary components, and perform tests, the Cisco Packet Tracer application was used. Routing protocols and server setups were also carried out here. Consequently, this simulation contributed to verifying the effective operation of the designed project.

In summary, this project aims to demonstrate how network infrastructure can be provided to a region using drones in the event of a disaster.

INDEX TERMS Network, Communication, Drone, Drone Technology, Network Infrastructure, Network Services, Network Design, Disaster Recovery, Network Demo

I. INTRODUCTION

This project focuses on establishing network infrastructure in the earthquake-affected cities of Adana, Urfa, and Hatay, following the devastating 7.8 magnitude earthquake that occurred on February 6, 2023, at 4:17 AM. This event, which has been recognized as one of the most significant disasters of the 21st century, impacted 10 provinces. The earthquake highlighted the critical need for deployable communication systems in emergency scenarios. The main goal of this project is to facilitate communication among people during such emergencies.

In the project scenario, Adana, Urfa, and Hatay were selected as representative earthquake-affected cities. Konya, chosen for its minimal earthquake risk, was designated to host the servers, ensuring their safety in the event of another earthquake. Various devices, including drones, switches, routers, DHCP servers, Web Servers, DNS servers, and access points, were utilized to establish the network infrastructure.

Drones are a key component of this project, used to provide optimal mobile access points to individuals trapped under rubble. In this scenario, the DHCP server, Web Server, and DNS server are all located in Konya. A "Main" router connects Konya to the three earthquake-affected cities, ensuring network connectivity across all locations. Additionally, each affected city is equipped with its own router, switch, and access points carried by drones. In the simulation, all devices

FIGURE 1. Drone

receive IP addresses automatically from the DHCP server, enabling seamless communication.

This project aims to demonstrate how drones can be used to establish network infrastructure in disaster-stricken areas. Simulations conducted with the Cisco Packet Tracer application facilitated the planning and testing of the necessary infrastructure. Routing protocols and server setups were also implemented using this tool. Ultimately, these simulations helped verify the effective functionality of the proposed project.

THE EXPERIMENTAL DESIGN PROBLEM: Key challenges include automatic IP address assignment by the DHCP server, managing data load with a main router, and designing redundancy for reliability. Simulation tools like Cisco Packet Tracer are used to test and validate the network design, ensuring it meets the requirements for rapid deployment and resilient communication in disaster-stricken areas.

II. MATERIALS

A. SWITCHES

2950-T24 Switch:

A switch is a networking device used in computer networks to connect devices together and facilitate communication between them. It operates at the data link layer of the OSI model and is essential for creating local area networks (LANs). The primary function of a switch is to receive data packets from connected devices, analyze the destination address of each packet, and forward it to the appropriate destination. By doing so, switches enable efficient and direct communication between devices within the same network segment, reducing network congestion and improving overall network performance.

FIGURE 2. 2950-T24 Switch

B. DRONE

Due to the chaos on the ground caused by building debris during an earthquake, drones are used to carry the Access Points. These drones are positioned at regular intervals to ensure people have access to the internet. People can connect to the Access Points on the drones and have free Wi-Fi access.

C. ACCESS POINT

Access Point (AP) is used to extend the wireless coverage of an existing network and allow multiple wireless devices to connect to the network. During an earthquake, drones equipped with Access Point can be deployed to provide wireless network coverage in areas where ground-based infrastructure is damaged or unavailable. This ensures that people can still access the internet for communication, information, and emergency services.

D. ROUTER

A router is a device that connects different computer networks and directs data packets between them. It determines the best path for data to travel, ensuring efficient communication between networks. Routers also provide features like network address translation and firewall protection, making them essential for connecting to the internet and ensuring network security.

E. SERVER

Servers are powerful computers or software systems that provide resources, services, or functionality to other computers, known as clients, within a network. They are used for various purposes, such as hosting websites, storing and managing data, running applications, managing network resources, and providing email services. Servers are designed to be reliable, scalable, and accessible, ensuring that clients can access the resources they need efficiently and securely. DHCP, Web and DNS servers can be given as examples.

F. EQUATIONS

Some of the important equations are given below for the Network Infrastructure.

Konya Router:

$$\begin{aligned} 192.168.80.1 &= 11000000101010000101000000000001 \\ 255.255.255.0 &= 11111111111111111111111100000000 \\ 192.168.80.0 &= 11000000101010000101000000000000 \end{aligned} \tag{1}$$

DHCP Server (Konya):

$$\begin{aligned} 192.168.80.100 &= 11000000101010000101000001100100 \\ 255.255.255.0 &= 11111111111111111111111100000000 \\ 192.168.80.0 &= 11000000101010000101000000000000 \end{aligned} \tag{2}$$

Laptop8 (Hatay):

$$\begin{aligned} 192.168.81.16 &= 11000000101010000101000100010000 \\ 255.255.255.0 &= 11111111111111111111111100000000 \\ 192.168.81.0 &= 11000000101010000101000100000000 \end{aligned} \tag{3}$$

III. METHODOLOGY

A. VLANS

In this project, Virtual Local Area Networks (VLANs) are utilized to enhance network segmentation and improve performance across the disaster-affected areas. VLANs allow for the logical separation of network traffic, ensuring that different types of data, such as emergency communications, administrative information, and public internet access, are isolated from each other. This segmentation minimizes network congestion and enhances security by limiting broadcast domains and controlling access to sensitive data. By implementing VLANs, the project ensures that critical communications remain prioritized and uninterrupted, facilitating efficient and secure information flow between the drones, servers, and other network components deployed in Adana, Urfa, Hatay, and the central hub in Konya.

B. SUBNETS

In this project, subnets are employed to organize and manage the network more efficiently across the affected regions of Adana, Urfa, and Hatay, as well as the central hub in Konya. By dividing the network into smaller subnets, each city and its corresponding devices (drones, routers, switches, and access points) are allocated a distinct IP address range. This subdivision not only reduces network congestion by limiting broadcast traffic but also enhances security by isolating different segments of the network. Proper subnetting ensures that the IP address space is utilized optimally, facilitating streamlined routing and easier management of the dynamic network environment crucial for effective communication and coordination during disaster response efforts.

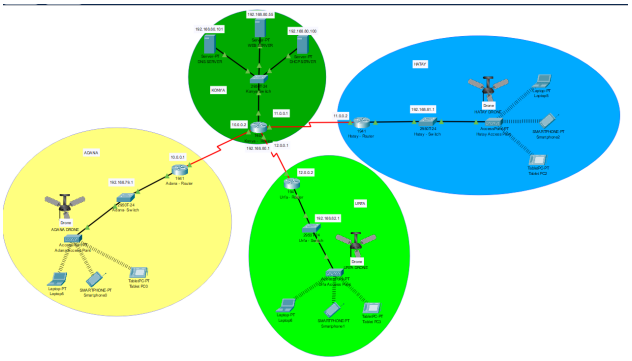

FIGURE 3. Project network setup on Cisco Packet Tracer Platform

C. IP ADDRESS ALLOCATION AND MANAGEMENT:

In this project, IP address allocation and management are strategically divided between static and dynamic assignments to ensure efficient network operation. Routers, servers, and switches in the cities of Adana, Urfa, Hatay, and the central hub in Konya are assigned static IP addresses. This approach provides stability and simplifies network configuration by ensuring that critical infrastructure components always have predictable and consistent IP addresses. Meanwhile, end-user devices, which include the personal devices of individuals within the network, receive IP addresses dynamically through the DHCP server located in Konya. The DHCP server automatically assigns IP addresses to these devices, facilitating seamless connectivity and reducing the administrative burden of manually configuring each device. This combination of static and dynamic IP allocation optimizes network performance and ensures robust communication during disaster response efforts.

IV. IMPLEMENTATION

The implementation phase involves setting up the network devices and configurations in Cisco Packet Tracer. Following steps have been implemented.

A. NETWORK DEVICE CONFIGURATION

The implementation phase begins with setting up the network devices required for the project in Cisco Packet Tracer. This includes configuring routers, switches, servers, DHCP servers, and drones to establish the network infrastructure. Each device is meticulously configured to ensure seamless communication and optimal performance.

B. STATIC IP ADDRESS ASSIGNMENT

As per project specifications, static IP addresses are assigned to routers, servers, and switches located in the cities of Adana, Urfa, Hatay, and the central hub in Konya. This static assignment ensures stability and predictability in network addressing, facilitating efficient routing and management of critical infrastructure components.

C. DYNAMIC IP ADDRESS ALLOCATION

End-user devices, such as personal smartphones and laptops, receive IP addresses dynamically through the DHCP server located in Konya. This dynamic allocation simplifies the process of connecting devices to the network, allowing users to seamlessly access communication services without manual configuration.

D. VLAN CONFIGURATION AND SUBNETTING

During the implementation phase, VLANs are configured to segment network traffic and enhance security and performance, while subnetting is employed to organize and manage IP address allocation effectively across the network. VLANs logically isolate different types of data, such as emergency communications and administrative information, ensuring efficient data flow while minimizing network congestion and improving security. Subnets are then configured to allocate distinct IP address ranges to each city and its associated devices, optimizing routing and facilitating streamlined communication between different network segments. This combined approach of VLAN configuration and subnetting ensures the efficient operation of the network infrastructure, supporting seamless connectivity and effective communication during critical situations.

E. TESTING AND VALIDATION

Throughout the implementation phase, rigorous testing and validation procedures are conducted to ensure the functionality and reliability of the network infrastructure. Simulation tools like Cisco Packet Tracer are utilized to simulate real-world scenarios, identify potential issues, and verify the effectiveness of configurations before actual deployment.

F. EXPERIMENTAL DESIGN LIMITATIONS

Despite the comprehensive approach to network infrastructure development, several constraints exist within the project's experimental design. Simulation-based testing in Cisco Packet Tracer, while valuable for validation, may not fully reflect real-world conditions, potentially leading to performance variations. Additionally, scalability concerns arise, particularly regarding network expansion beyond initial specifications. Resource limitations, including budget constraints and hardware availability, may impact the project's scope and resilience. External factors such as power supply reliability, internet connectivity, and drone operations also influence network functionality. Human error and training gaps pose risks, requiring rigorous training and documentation. Regulatory compliance and environmental factors further complicate network deployment and operation. Addressing these limitations necessitates continuous monitoring and adaptation of the network infrastructure to ensure optimal performance during emergency scenarios.

V. DISCUSSION AND CONCULUSION

A. DISCUSSIONS

The project confronts various challenges and uncertainties in its experimental design, including the difficulty of accurately simulating real-world conditions, scalability concerns beyond initial specifications, and inherent impossibilities such as human error and unforeseen environmental factors. Cost-based problems, such as budget constraints and resource availability, further complicate the project's feasibility and scope. Despite these obstacles, continuous monitoring, adaptation, and optimization of the network infrastructure are emphasized to enhance its performance and resilience. Moving forward, ongoing evaluation, technological advancements are essential for addressing remaining uncertainties and maximizing the project's effectiveness in emergency communication scenarios.

B. CONCLUSION

In conclusion, this project aims to provide the necessary infrastructure to disaster-stricken areas using drones. While encountering possible challenges in real-life scenarios is conceivable, the project's objective is to offer a different solution to the question of how network infrastructure can be provided to disaster zones.

C. COPYRIGHT ISSUE

This project complies with all pertinent copyright and usage guidelines, guaranteeing the absence of any intellectual property rights infringement.

ACKNOWLEDGMENT

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BARAN ÇAKMAK DEMIR was born on May 22, 2001, in Sakarya. He started his primary education at Bahçelievler Primary School and continued to Bahçelievler Middle School for his middle school education. After the high school entrance exam, he was admitted to Sakarya Anatolian High School, where he continued his high school education and graduated. Subsequently, he was admitted to the computer engineering department at Atılım University for his undergraduate program. After his first year, he transferred to the computer engineering department at Manisa Celal Bayar University, where he is currently continuing his studies in computer engineering.

He completed his summer internship at Tırsan Treyler Sanayi ve Ticaret A.Ş. There, he worked in the technology management department on tasks such as cloud management, network management, and server management.

APPENDIX A
MÜDEK PROGRAM ÇIKTILARI

COMPUTER NETWORKS MidTERM
Computer Engineering Department
Manisa Celal Bayar University

MÜDEK – Course Learning OutComes and Components

CSE 3136	PÇB1	PÇB2	PÇB3	PÇB4	PÇB5	PÇB6	PÇB7	PÇB8	PÇB9	PÇB10	PÇB11	PÇB12	PÇB13	PÇB14	PÇB15	PÇB16	PÇB17	PÇB18	PÇB19	PÇB20	PÇB21	PÇB22	PÇB23	PÇB24	PÇB25	PÇB26	PÇB27	PÇB28
Comp Network PÇB	✓	✓		✓	✓	✓	✓	✓	✓	✓			✓				✓				✓		✓					

PÇ1 Matematik, fen bilimleri ve ilgili mühendislik disiplinine özgü konularda yeterli bilgi birikimi; bu alanlardaki kuramsal ve uygulamalı bilgileri, karmaşık mühendislik problemlerinde kullanabilme becerisi.	**PÇB1** Matematik, fen bilimleri ve ilgili mühendislik disiplinine özgü konularda yeterli bilgi birikimi; **PÇB2** Bu alanlardaki kuramsal ve uygulamalı bilgileri, karmaşık mühendislik problemlerinin çözümünde kullanabilme becerisi
PÇ2 Karmaşık mühendislik problemlerini tanımlama, formüle etme ve çözme becerisi; bu amaçla uygun analiz ve modelleme yöntemlerini seçme ve uygulama becerisi.	**PÇB3** **PÇB4** Bu amaçla uygun analiz ve modelleme yöntemlerini seçme ve uygulama becerisi.
PÇ3 Karmaşık bir sistemi, süreci, cihazı veya ürünü gerçekçi kısıtlar ve koşullar altında, belirli gereksinimleri karşılayacak şekilde tasarlama becerisi; bu amaçla modern tasarım yöntemlerini uygulama becerisi	**PÇB5** Karmaşık bir sistemi, süreci, cihazı veya ürünü gerçekçi kısıtlar ve koşullar altında, belirli gereksinimleri karşılayacak şekilde tasarlama becerisi; **PÇB6** Bu amaçla modern tasarım yöntemlerini uygulama becerisi.
PÇ4 Mühendislik uygulamalarında karşılaşılan karmaşık problemlerin analizi ve çözümü için gerekli olan modern teknik ve araçları seçme ve kullanma becerisi; bilişim teknolojilerini etkin bir şekilde kullanma becerisi.	**PÇB7** Mühendislik uygulamalarında karşılaşılan karmaşık problemlerin analizi ve çözümü için gerekli olan modern teknik ve araçları seçme ve kullanma becerisi; **PÇB8** Bilişim teknolojilerini etkin bir şekilde kullanma becerisi
PÇ5 Karmaşık mühendislik problemlerinin veya disipline özgü araştırma konularının incelenmesi için deney tasarlama, deney yapma, veri toplama, sonuçları analiz etme ve yorumlama becerisi.	**PÇB9** Karmaşık mühendislik problemlerinin veya disipline özgü araştırma konularının incelenmesi için deney tasarlama becerisi **PÇB10** Deney yapma, veri toplama, sonuçlarını analiz etme ve yorumlama becerisi.
PÇ6 Disiplin içi ve çok disiplinli takımlarda etkin biçimde çalışabilme becerisi; bireysel çalışma becerisi.	**PÇB11 PÇB12** **PÇB13** Bireysel çalışma becerisi.
PÇ7 Türkçe sözlü ve yazılı etkin iletişim kurma becerisi; en az bir yabancı dil bilgisi; etkin rapor yazma ve yazılı raporları anlama, tasarım ve üretim raporları hazırlayabilme, etkin sunum yapabilme, açık ve anlaşılır talimat verme ve alma becerisi.	**PÇB14 PÇB15 PÇB16** **PÇB17** Tasarım ve üretim raporları hazırlayabilme becerisi **PÇB18 PÇB19**
PÇ8 Yaşam boyu öğrenmenin gerekliliği konusunda farkındalık; bilgiye erişebilme, bilim ve teknolojideki gelişmeleri izleme ve kendini sürekli yenileme becerisi	**PÇB20** **PÇB21** Bilgiye erişebilme, bilim ve teknolojideki gelişmeleri izleme ve kendini sürekli yenileme becerisi.
PÇ9 Etik ilkelerine uygun davranma, mesleki ve etik sorumluluk ve mühendislik uygulamalarında kullanılan standartlar hakkında bilgi.	**PÇB22** **PÇB23** Mühendislik uygulamalarında kullanılan standartlar hakkında bilgi.

FIGURE 4. MUDEK Program Çıktıları Bileşenleri