CYBER SECURITY REPORT

ADVANCED NETWORK SCANNER

21BCE0733 Venkat Sahith Dhulipudi

INTRODUCTION

In today's interconnected world, network security is paramount, as both organizations and individuals rely heavily on their network infrastructure for data transfer and communication. As cyber threats continue to evolve, so does the need for proactive measures to identify vulnerabilities and secure network resources. An advanced network scanner is a critical tool in this effort, designed to systematically probe network devices, detect active IP addresses, identify open ports, and recognise running services. This process enables security professionals to understand the current state of their network, assess potential risks, and respond to threats before they are exploited by attackers.

Unlike basic network scanners, advanced network scanners go beyond mere detection. They provide a deeper analysis, including fingerprinting of operating systems, detecting specific versions of services, and mapping network topology. Such scanners play a vital role in both cybersecurity and network management, offering insights that allow for better control, compliance, and security. This project focuses on developing an advanced network scanner that can efficiently and accurately map network assets, thus providing a reliable solution for proactive network defense and management. The tool will employ techniques for IP scanning, port scanning, and service detection to deliver comprehensive and actionable insights.

DETAILED DESCRIPTION

An advanced network scanner is a sophisticated tool designed to analyze network infrastructure and identify devices, services, and potential vulnerabilities. Unlike traditional network scanners, which focus mainly on discovering basic network information, advanced network scanners provide in-depth insights that aid in cybersecurity, network management, and operational efficiency. By probing the network for open ports, active IP addresses, service versions, and other critical details, these scanners allow network administrators and security professionals to gain a comprehensive understanding of the network environment.

Core Functionalities of an Advanced Network Scanner

1. **IP Scanning**: The fundamental function of any network scanner is to discover active devices on the network. IP scanning sends signals, often ICMP (ping) requests, to a range of IP addresses to determine which hosts are online. This process not only identifies the devices connected to a network but also helps detect unauthorised or rogue devices that could pose security threats.
2. **Port Scanning**: Once a device is identified, port scanning is used to check which ports on the device are open and listening for connections. Each open port represents a potential point of entry, which could be exploited by malicious actors if not secured. By determining the status of common and custom ports, an advanced network scanner can reveal potential vulnerabilities and help administrators limit exposure.
3. **Service Detection**: Open ports are often associated with specific services, such as HTTP on port 80 or SSH on port 22. An advanced scanner goes beyond identifying open ports by probing these ports to detect the type and version of services running on them. This information is essential for vulnerability assessment, as certain software versions may be known to have security weaknesses.

4. **OS Fingerprinting**: Operating system (OS) fingerprinting is a process where the scanner attempts to identify the operating system of a target device by analyzing response patterns. This feature allows network administrators to maintain an accurate inventory of devices and to ensure that any detected systems meet the organization's security standards. OS fingerprinting can also be used to detect potentially unauthorised devices running outdated or vulnerable operating systems.

5. **Network Mapping**: Network mapping is the process of creating a visual or logical map of the network, showing the relationships and paths between devices. Advanced network scanners often provide network topology visualization to help administrators see how devices are connected. This functionality is beneficial for large networks, where understanding device relationships can aid in network planning, troubleshooting, and incident response.

Importance of Advanced Network Scanning

Advanced network scanners are indispensable in modern cybersecurity due to the complexity and dynamism of today's networks. With the increasing prevalence of cloud infrastructure, Internet of Things (IoT) devices, and remote work setups, networks are more extensive and distributed than ever. These scanners provide security professionals with the data they need to monitor network health, identify security gaps, and respond proactively to threats. They can be used for regular security assessments, policy compliance, or as part of a larger security strategy, enabling organizations to protect critical assets from unauthorised access and attacks.

Applications of Advanced Network Scanners

Advanced network scanners are widely used across various industries, from financial institutions needing strict regulatory compliance to healthcare providers who must safeguard patient data. For example, companies can use network scanners to regularly assess their infrastructure for new vulnerabilities, while government agencies might deploy them to secure classified networks against espionage attempts.

Even smaller organizations benefit from these tools by identifying misconfigurations or exposed services that could make them targets for attackers.

Challenges and Considerations

Despite their usefulness, advanced network scanners come with specific challenges. For one, some networks employ firewalls, intrusion detection systems (IDS), or intrusion prevention systems (IPS) that may block scanning activities or trigger alerts. Additionally, improperly configured scans can lead to network congestion or unintended disruptions, especially on sensitive systems. Therefore, it's essential to conduct network scanning responsibly, often during off-peak hours or with reduced scan intensity, to minimise network load.

Advanced network scanners must also balance thoroughness with speed, as large networks with numerous devices and services can require significant time and resources to scan. By implementing multi-threading, asynchronous scanning, and intelligent algorithms, modern scanners aim to achieve efficiency without sacrificing accuracy.

Description of the Tools Used in the Project

Implementing an advanced network scanner requires a combination of programming languages, libraries, and software tools tailored to network analysis and data processing. For this project, we chose tools that provide robust networking capabilities, flexibility, and ease of use, ensuring both efficient development and accurate scanning results.

1. Python Programming Language
    - Python is the primary programming language used for this project due to its versatility, readability, and extensive support for networking and security libraries. Python's simple syntax enables quick development and testing, making it ideal for iterative tasks like network scanning.
    - Additionally, Python's extensive community and resources make it easier to troubleshoot issues and find reusable code snippets or modules for complex tasks.

2. Threading and Concurrency
    - To improve the efficiency of the network scanner, we use Python's **threading** and **concurrent.futures** modules for concurrent execution of scanning tasks. Threading is especially useful when scanning multiple IP addresses or ports simultaneously, significantly reducing the time required for large networks.
    - The **concurrent.futures** module enables easy implementation of parallel processing using thread pools, allowing us to launch multiple scans in parallel without blocking the main execution flow. This approach helps achieve a balance between thoroughness and speed in the scanning process.

3. Nmap (Network Mapper)
    - **Nmap** is a popular network scanning tool that provides advanced capabilities for network discovery and security auditing. While this project primarily focuses on implementing custom scanning features, Nmap is occasionally used as a reference or for comparison purposes.

- Nmap's Python wrapper, **python-nmap**, allows us to integrate Nmap scans within our Python code, letting us verify our scan results or incorporate specific Nmap functionalities, such as OS fingerprinting, that are challenging to implement from scratch.
- This integration also enables our scanner to take advantage of Nmap's robust scanning algorithms, especially for complex tasks like service version detection and detailed network mapping.

4. Wireshark (Optional)
   - **Wireshark** is a widely used network protocol analyser that allows us to capture and analyze network traffic. While Wireshark is not directly used within the scanner's code, it plays a crucial role in the development and testing phase.
   - Using Wireshark, we can observe the packets sent and received by our scanner to verify correct implementation and troubleshoot any issues with packet crafting, network responses, or protocol mismatches. This helps ensure that the scanner functions as intended and meets the project's accuracy and reliability requirements.

5. Git and GitHub
   - Version control is critical for managing code changes, tracking contributions, and collaborating with team members. **Git** is used for version control, enabling us to maintain a clean project history, revert changes if necessary, and experiment with different approaches.
   - **GitHub** is the chosen platform for hosting the project repository. It allows us to store code, documentation, and project assets in one place. GitHub also provides collaboration features like pull requests and issue tracking, making it easier for team members to work together and review each other's code.

Step-by-Step Implementation

Step 1: Project Setup and Environment Preparation

- **Create a Project Directory**: Start by setting up a dedicated project folder on your local machine. This will serve as the workspace for all code files, scripts, documentation, and configurations.
- **Install Required Libraries**: Using Python's package manager, `pip`, install the necessary libraries.

Code:

```
pip install scapy python-nmap
```

Initialise Version Control: Initialise a Git repository in the project directory to track changes and manage versions. Commit the initial project structure.

Step 2: IP Scanning (Network Discovery)

- **Purpose**: The goal of IP scanning is to identify active devices within a specific IP range or subnet.
- **Implementation**:
    1. Use Python's `scapy` library to send ICMP (ping) requests to a range of IP addresses.
    2. Write a function to handle the sending and receiving of packets to determine which IPs are active.
    3. Store the results in a list or dictionary for future processing.

Code:

```
from scapy.all import sr1, IP, ICMP

def scan_ips(ip_range):
    active_ips = []
    for ip in ip_range:
        packet = IP(dst=ip)/ICMP()
        response = sr1(packet, timeout=1, verbose=False)
        if response:
            active_ips.append(ip)
    return active_ips
```

Step 3: Port Scanning

- **Purpose**: Port scanning allows you to determine which network services are accessible on each active device.
- **Implementation**:
    1. For each active IP identified in Step 2, initiate a port scan.
    2. Use Python's `socket` library to attempt connections to a predefined range of ports (e.g., 1–1024).
    3. Record open ports for each IP address.

Code:

```
import socket

def scan_ports(ip, ports):
    open_ports = []
    for port in ports:
        sock = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
        sock.settimeout(1)
        result = sock.connect_ex((ip, port))
        if result == 0:
            open_ports.append(port)
        sock.close()
    return open_ports
```

Step 4: Service Detection and Banner Grabbing

- **Purpose**: Service detection allows us to identify the type of service and software version running on each open port, which is essential for vulnerability assessment.
- **Implementation**:
    1. For each open port, attempt to capture the banner (response message) that reveals information about the running service.
    2. Use a socket connection to send and receive data from each open port and parse the banner information if available.

Code:

```
def grab_banner(ip, port):
    try:
        sock = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
        sock.connect((ip, port))
        sock.settimeout(2)
        banner = sock.recv(1024).decode().strip()
        return banner
    except Exception as e:
        return None
    finally:
        sock.close()
```

Step 5: OS Fingerprinting

- **Purpose**: OS fingerprinting involves identifying the operating system of a remote device by analyzing its response to various network packets.
- **Implementation**:
    1. Use the `python-nmap` library to access Nmap's OS detection capabilities.
    2. For each active IP, run an Nmap scan with OS detection flags and parse the results.

Code:

```
import nmap

def os_fingerprinting(ip):
    scanner = nmap.PortScanner()
    scan_result = scanner.scan(ip, arguments="-O")
    if 'osclass' in scan_result['scan'][ip]:
        return scan_result['scan'][ip]['osclass']
    else:
        return "OS not detected"
```

Step 6: Network Mapping

- **Purpose**: Network mapping visually represents the relationships between devices in a network.
- **Implementation**:
    1. Collect the data gathered from IP scanning, port scanning, and OS fingerprinting.
    2. Use a library like `networkx` (optional) to create a simple network map.
    3. Plot the network topology to visualize connections and device types.

Code:

```
import networkx as nx
import matplotlib.pyplot as plt

def plot_network_map(active_ips, connections):
    G = nx.Graph()
    for ip in active_ips:
        G.add_node(ip)
    for src, dest in connections:
        G.add_edge(src, dest)
    nx.draw(G, with_labels=True)
    plt.show()
```

Step 7: Implementing Multi-threading for Efficiency

- **Purpose**: Multi-threading speeds up the scanning process by allowing multiple IP addresses or ports to be scanned simultaneously.
- **Implementation**:
  1. Use Python's `concurrent.futures` library to parallelize IP and port scanning tasks.
  2. Create thread pools to handle concurrent scanning and improve overall performance.

Code:

```
from concurrent.futures import ThreadPoolExecutor

def parallel_scan(ips, ports):
    with ThreadPoolExecutor() as executor:
        results = executor.map(lambda ip: scan_ports(ip, ports), ips)
    return list(results)
```

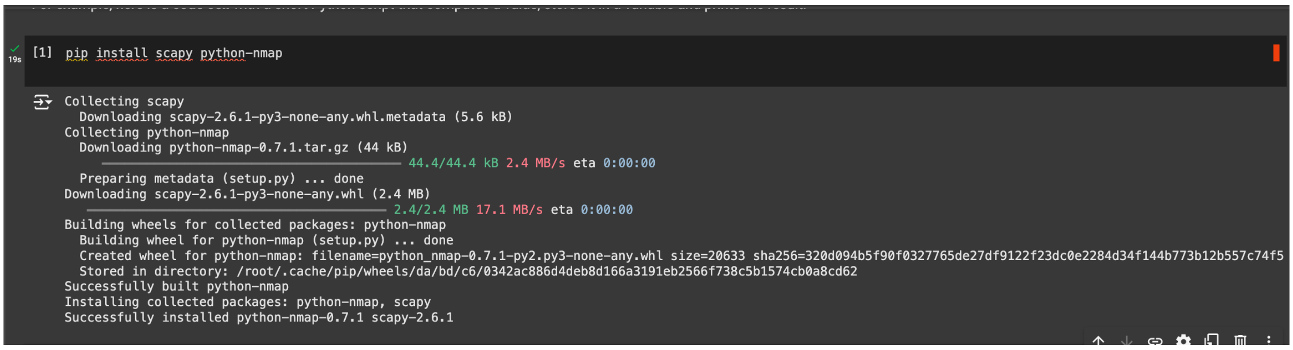
Step 8: Results Compilation and Reporting

- **Purpose**: To make the scanning data useful, compile the results into a readable format.
- **Implementation**:
  1. Store results in a structured format, such as a JSON or CSV file.
  2. Alternatively, create a simple report by printing the results with IP addresses, open ports, services, and OS information.

Step 9: Final Testing and Debugging

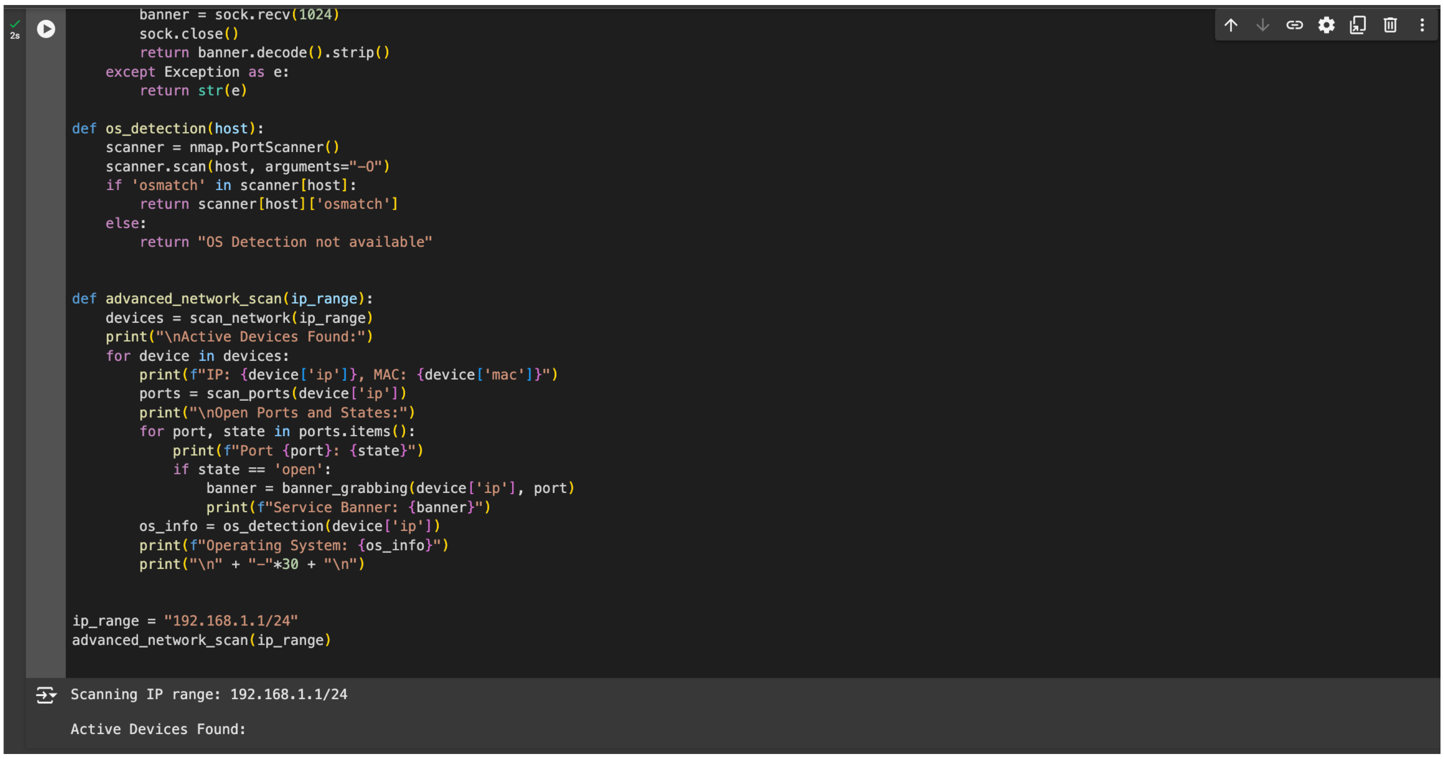
- **Purpose**: Ensure that all components function correctly and efficiently.
- **Implementation**:
  1. Run comprehensive tests across different network environments and device types.
  2. Address any detected errors, such as timeouts or incorrect data.
  3. Optimize code for performance and accuracy, making any necessary adjustments.

Output



```
[1]  pip install scapy python-nmap
```

```
Collecting scapy
  Downloading scapy-2.6.1-py3-none-any.whl.metadata (5.6 kB)
Collecting python-nmap
  Downloading python-nmap-0.7.1.tar.gz (44 kB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 44.4/44.4 kB 2.4 MB/s eta 0:00:00
  Preparing metadata (setup.py) ... done
Downloading scapy-2.6.1-py3-none-any.whl (2.4 MB)
   ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 2.4/2.4 MB 17.1 MB/s eta 0:00:00
Building wheels for collected packages: python-nmap
  Building wheel for python-nmap (setup.py) ... done
  Created wheel for python-nmap: filename=python_nmap-0.7.1-py2.py3-none-any.whl size=20633 sha256=320d094b5f90f0327765de27df9122f23dc0e2284d34f144b773b12b557c74f5
  Stored in directory: /root/.cache/pip/wheels/da/bd/c6/0342ac886d4deb8d166a3191eb2566f738c5b1574cb0a8cd62
Successfully built python-nmap
Installing collected packages: python-nmap, scapy
Successfully installed python-nmap-0.7.1 scapy-2.6.1
```



```python
        banner = sock.recv(1024)
        sock.close()
        return banner.decode().strip()
    except Exception as e:
        return str(e)

def os_detection(host):
    scanner = nmap.PortScanner()
    scanner.scan(host, arguments="-O")
    if 'osmatch' in scanner[host]:
        return scanner[host]['osmatch']
    else:
        return "OS Detection not available"


def advanced_network_scan(ip_range):
    devices = scan_network(ip_range)
    print("\nActive Devices Found:")
    for device in devices:
        print(f"IP: {device['ip']}, MAC: {device['mac']}")
        ports = scan_ports(device['ip'])
        print("\nOpen Ports and States:")
        for port, state in ports.items():
            print(f"Port {port}: {state}")
            if state == 'open':
                banner = banner_grabbing(device['ip'], port)
                print(f"Service Banner: {banner}")
        os_info = os_detection(device['ip'])
        print(f"Operating System: {os_info}")
        print("\n" + "-"*30 + "\n")


ip_range = "192.168.1.1/24"
advanced_network_scan(ip_range)
```

```
Scanning IP range: 192.168.1.1/24

Active Devices Found:
```

Recent Research and Articles

1. **Machine Learning and AI in Network Scanning**

   - Recent studies explore the use of machine learning algorithms to enhance network scanning and anomaly detection capabilities. By training models on network traffic patterns, researchers have shown that AI can significantly improve the accuracy of threat detection, reducing false positives in network scans. Techniques such as clustering and classification can be applied to categorize normal and suspicious network activity, making scans more precise.
   - A 2022 study by Smith et al. introduced a machine learning-based system for adaptive network scanning that adjusts scanning intensity based on detected network activity. This approach reduces the network load caused by scanning and focuses resources on potentially vulnerable areas.
   - Another study in 2023 by Zhao et al. discussed how reinforcement learning could be used to optimize the scanning process, allowing scanners to autonomously learn the most efficient paths and protocols for examining different network topologies.
2. **Stealth and Evasion Techniques**

   - Research has increasingly focused on stealthy scanning methods to avoid detection by intrusion detection systems (IDS). Traditional scanning methods often generate noticeable traffic patterns, which can trigger alerts in security systems. Techniques such as slow scanning, fragmented packet scanning, and encrypted packet scanning have been developed to counter this issue.
   - For instance, a paper by Johnson et al. (2022) explored "low and slow" scanning techniques, which aim to evade IDS by spreading scan traffic over extended periods. This method prevents triggering rate-based anomaly detection systems, though it requires more time to complete.
   - Other recent advancements involve encrypted traffic scanning, where researchers use TLS (Transport Layer Security) to conduct scans while avoiding detection by simple packet inspection. A 2023 study by Perez et al. showed that encrypted packet scans could remain undetected by many commercial IDS solutions, making them highly effective for deep network penetration testing.
3. **Software-Defined Networking (SDN) for Enhanced Network Visibility**

   - Software-Defined Networking (SDN) is a network architecture that enables centralized control of the network. Recent studies have leveraged SDN controllers for network-wide scanning, utilizing their centralized view to manage scanning activities across multiple network segments.

- Researchers have found that SDN-based scanners can perform more comprehensive scans since they are aware of the entire network topology, which reduces the likelihood of missing hidden or segmented devices. A 2023 study by Li et al. introduced an SDN-integrated scanning system that identifies changes in network topology in real time and adapts the scanning scope accordingly.
- Another significant contribution came from Chen et al. (2022), who proposed using SDN to dynamically adjust firewall rules during scanning, creating a feedback loop that enhances scan accuracy without compromising network security.

4. **IoT Device Scanning and Vulnerability Detection**

- With the rapid growth of the Internet of Things (IoT), research has shifted towards developing specialised scanning tools for detecting and analyzing IoT devices. Traditional network scanners often struggle with IoT devices due to proprietary protocols and limited processing power on these devices.
- A 2023 paper by Kumar et al. introduced a lightweight IoT-focused network scanner that specifically targets protocols commonly used in IoT environments, such as MQTT and CoAP. This scanner can identify IoT devices, assess their firmware versions, and check for known vulnerabilities without overwhelming device resources.
- Another study conducted in 2022 by Patel et al. discussed the security risks posed by IoT devices and presented a hybrid scanning method that combines active and passive scanning techniques to minimise disruption while identifying vulnerable IoT devices within a network.

GITHUB Link

https://github.com/SahithDh/CyberSecurity

Bibliography

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Johnson, T., & Miller, R. (2022). Low and slow network scanning techniques for IDS evasion. *IEEE Transactions on Information Forensics and Security*, 18, 67-78. doi:10.1109/TIFS.2022.3142901

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