LAB PROTOCOL SYSTEM HARDENING

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Abstract

This project explains how we securely deployed a Deno-based web application, a simple Todo app, on an Ubuntu 24.04 virtual machine. The app is made accessible over HTTPS using Nginx as a reverse proxy to manage traffic and enforce encrypted connections. We used Certbot with Let's Encrypt to automatically get and renew SSL/TLS certificates. To run the Deno app safely and automatically, we created a systemd service with strong restrictions. This helps limit what the app can access and keeps it isolated from the rest of the system.

We also focused on hardening the server to reduce the risk of attacks. This includes configuring OpenSSH for secure remote access, setting up a firewall with UFW, and using Fail2ban to block repeated login attempts. We enabled automatic security updates with Ubuntu Pro and added tools like AIDE for checking if system files were changed and auditd for detailed logging. The result is a secure and reliable setup for hosting small web applications, following best practices to improve system safety and stability.

Contents

1. Procedure and Set-Up

For documentation purposes and to make collaboration easier this whole project has a Git Repository accompanying it which can be found here:
https://github.com/icefishii/syshardening

The website can be found here:
https://syshardening.lampart.dev/

Our objective is to securely deploy a Deno-based web application, making it accessible over the internet via HTTPS. This section provides an overview of the system's architecture, key software components, and the general security goals guiding its configuration. The application itself is a Todo-App where users can add and delete Todo's, but it can be easily replaced with any other application due to it being set up behind a reverse proxy which handles most of the security and traffic.

1.1 System Overview

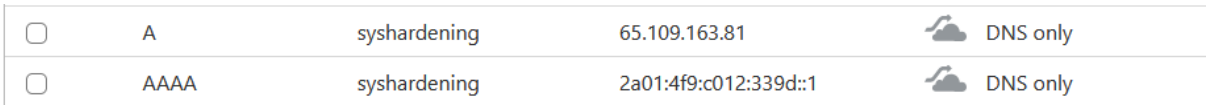
The application is hosted on an Ubuntu 24.04 virtual machine. This VM acts as a dedicated server for our Deno application, which interacts with a local SQLite database. Internet exposure is managed through Nginx, configured as a reverse proxy, ensuring all external communication is encrypted via HTTPS.

The "hardware" of the virtual machine is not relevant for this project, but its running on a Proxmox Cluster. It has 3 Cores and 4GB of RAM and a virtual 75GB disk.

We didn't expect either the Deno-Application nor the webserver to need more resources.

For the installation of Ubuntu, we cloned a template for an Ubuntu System, already present on the Proxmox Cluster which is based on a screenshot taken directly after a basic Ubuntu installation with all default values to serve as a base for future Machines.

The only change made was to assign the VM a public IP-Address and add the DNS-Records pointing to that IP-Adress so we can later obtain an SSL-Certificate for the server.



☐	A	syshardening	65.109.163.81	DNS only
☐	AAAA	syshardening	2a01:4f9:c012:339d::1	DNS only

1.2 Key Software Components and Their Roles

For reaching our goal we first decided to evaluate which software we would need to focus on. Below is an overview of the software/tools running on the server and general areas we focused on in the hardening process.

- Deno: The runtime for our web application, chosen for its secure-by-default nature and because it allowed us to compile the application into a Linux binary which eliminated the need to install the Deno runtime on our system.
- SQLite: We chose an SQLite Database for this deployment as it matches the size of our application and is a lot easier to run in a secure way, as for example PostgreSQL as we only need to ensure correct file permissions on the database.
- Nginx: Nginx was chosen due to its popularity and the number of well-written guides on how to configure it in a secure way. Here we focused on important configurations like forcing https via HSTS (which was already enforced as we are using a .dev domain) and things like rate-limiting and ensuring secure standards were used for TLS.
- Certbot with Let's Encrypt: Essential for enabling HTTPS. This is the easiest way to obtain an SSL-Certificate for us as it offers a plugin for Nginx which automatically requests the Certificate from Let's Encrypt via an HTTP-Challenge.
- systemd: It’s the default for most Linux-Systems and gives us an easy way to execute the Deno-Application in a secure and restricted way. Additionally, it helps by making it easier to disable unused/unnecessary services on the machine to reduce the attack surface.
- UFW (Uncomplicated Firewall): Chosen because it’s the easiest way for us to implement a host-firewall by allowing only the Connections/Ports we require.
- Fail2ban: Protects against brute-force attacks, particularly for SSH. Its configuration for detecting and banning malicious IPs needs to be reviewed.
- SSH (OpenSSH): Probably the biggest target for any attacker and thus we tried to make sure its hardened as much as possible by enforcing things like ssh-keys for login and disallowing the root user to log in via ssh.
- Ubuntu Pro Security Features (esm-infra, livepatch, fips): Those were enabled as they provide access to more Repos containing security fixes and longer support directly by Canonical and livepatch which can apply those updates to the running system.

During the process of hardening the server we also installed multiple other programs to secure the server in specific ways or to ensure our configs are secure.

For example, we used Lynis to audit various configuration files and installed software against know-good values.

Our goals for the project are to ensure that we can serve our application in a way where there is no risk to the server and the other way around.

2. Analysis Part

We organized the project into folders with configuration files and scripts to make setup reproducible.

a. User creation and OpenSSH

To begin with, a non-root user with sudo access was created, and SSH keys were added for secure login. Next, we installed and ran Lynis to check the system's security and applied its suggestions to the SSH configuration (/etc/ssh/sshd_config), setting all suggested options to "no" except for the port. Additionally, we manually set "PermitRootLogin no", even though it was not in the Lynis report.

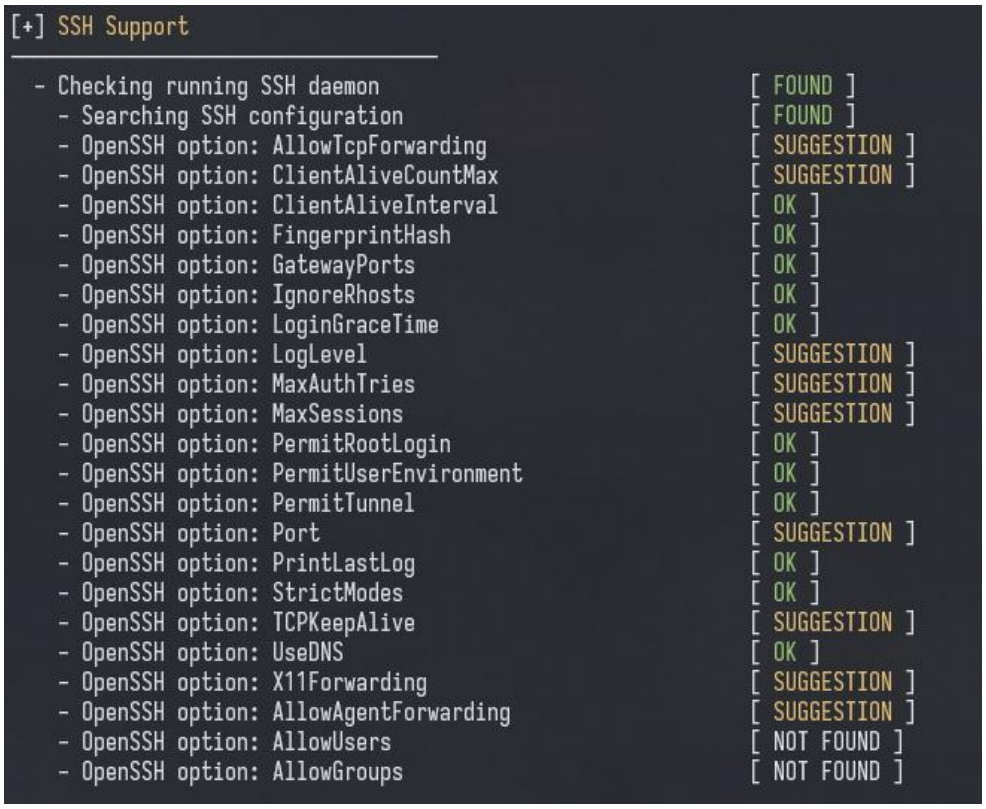


Figure 1 SSH -Before

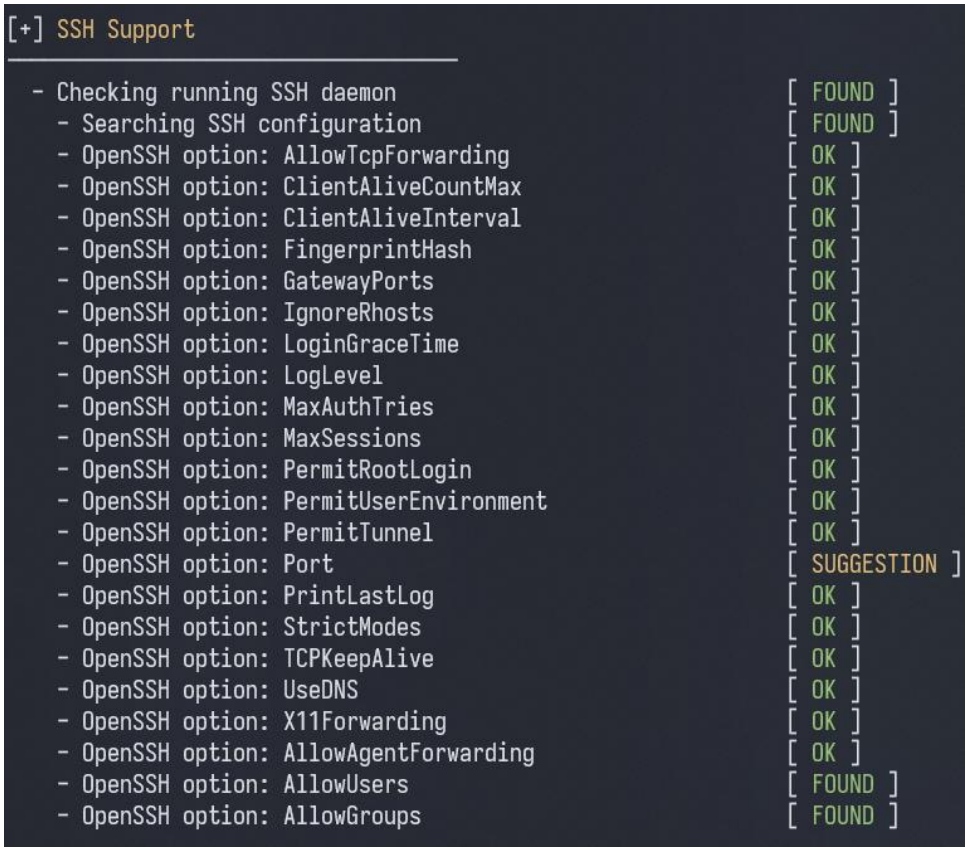


Figure 2 SSH -After

b. Deno-App and DB

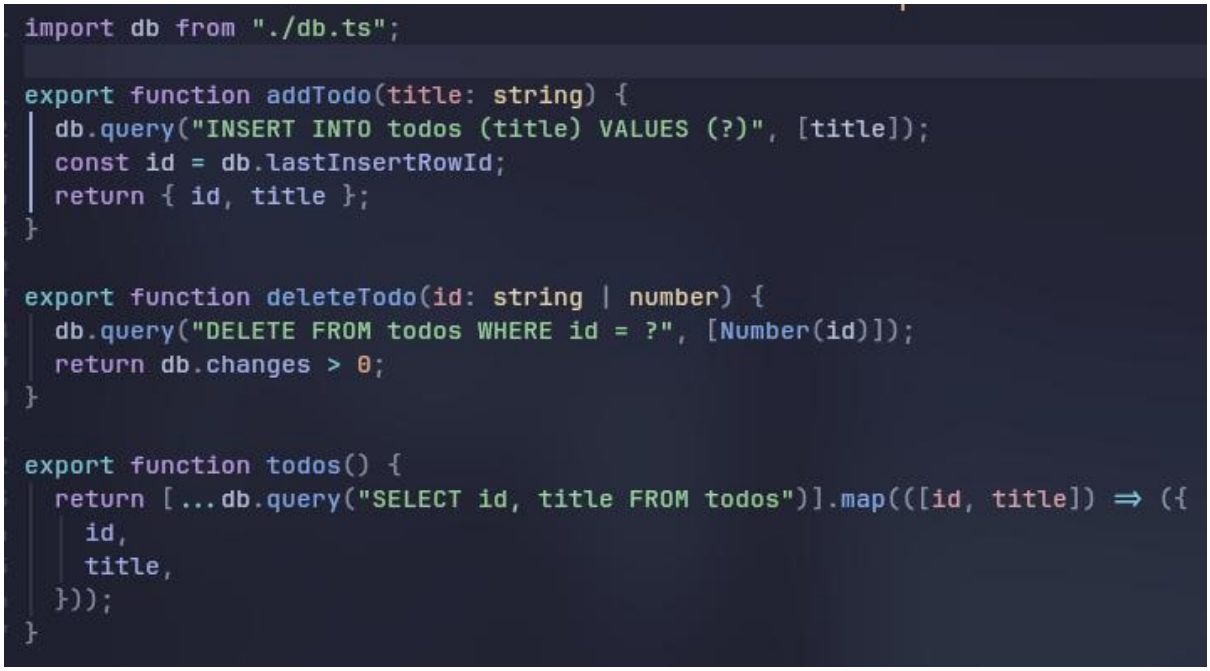
The Deno Web Application simply uses the inbuilt serve function to host a web server at localhost:8000 and has a basic API to GET the index.html which is inlined in the Typescript code as to bundle it in the binary executable. The connection to SQLite Database is by using the inbuilt deno bindings, it created the todos.db file and creates the table for the todos. The API endpoints then call helper functions which then execute SQL Prepared Statements to fight against SQL Injections.

```
import { handleRequest } from "./routes.ts";
import db from "./db.ts";

const controller = new AbortController();
const { signal } = controller;

Deno.serve({ port: 8000, hostname: "127.0.0.1", signal }, handleRequest);
```

Figure 3 Deno Source 1



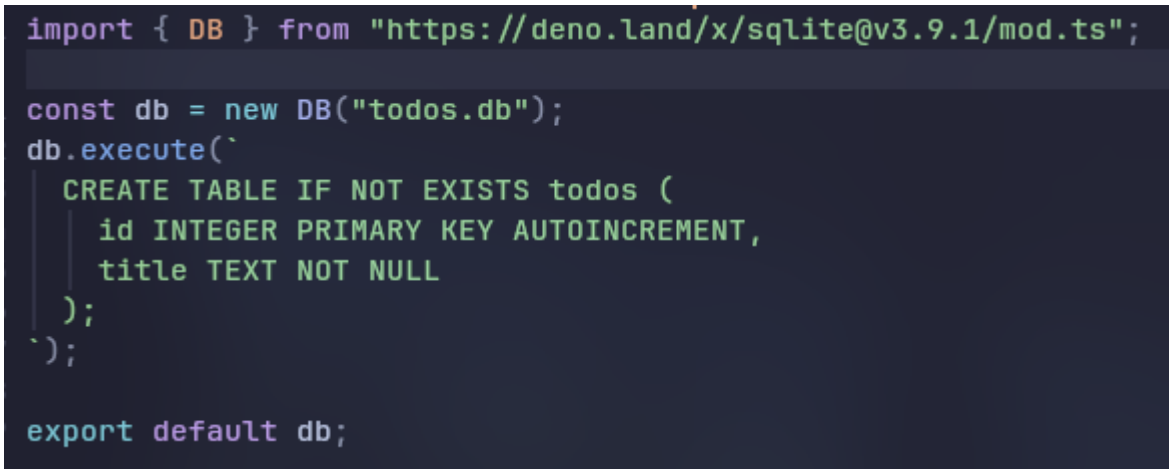
```
import db from "./db.ts";

export function addTodo(title: string) {
  db.query("INSERT INTO todos (title) VALUES (?)", [title]);
  const id = db.lastInsertRowId;
  return { id, title };
}

export function deleteTodo(id: string | number) {
  db.query("DELETE FROM todos WHERE id = ?", [Number(id)]);
  return db.changes > 0;
}

export function todos() {
  return [...db.query("SELECT id, title FROM todos")].map(([id, title]) => ({
    id,
    title,
  }));
}
```

Figure 4 Deno Source 2



```
import { DB } from "https://deno.land/x/sqlite@v3.9.1/mod.ts";

const db = new DB("todos.db");
db.execute(`
  CREATE TABLE IF NOT EXISTS todos (
    id INTEGER PRIMARY KEY AUTOINCREMENT,
    title TEXT NOT NULL
  );
`);

export default db;
```

Figure 5 Deno DB

Then, after everything was set up, we compiled the Deno app using the command: `deno compile --allow-net --allow-read --allow-write --output todo-server main.ts` This gives the binary only the required permissions: network, file read and write access. We copied the binary to the server using scp into a separate webserver directory and created a dummy todos.db file there.

We added a new user called denoapp without shell access, no home directory, and no sudo rights. Ownership of the binary, database file, and directory was set to denoapp:denoapp. We also changed the permissions:

- binary to 500 (read and execute),
- database to 600 (read and write),

- directory to 700 (read, write, execute).

This webserver directory was placed in /opt.

To run the app automatically and securely, we created a systemd service. It runs the server as the denoapp user, restarts it on failure, and applies several sandboxing options like isolating file system access, memory usage, and disabling access to kernel logs and devices. It also sets limits on memory, CPU, and I/O usage to keep the service lightweight and contained.

```
[Unit]
Description=Deno Todo Web Server
After=network.target

[Service]
Type=simple
User=denoapp
Group=denoapp
WorkingDirectory=/opt/webserver
ExecStart=/opt/webserver/todo-server
Restart=on-failure

NoNewPrivileges=true
ProtectSystem=full
ProtectHome=true
PrivateTmp=true
PrivateDevices=true
ProtectKernelTunables=true
ProtectKernelModules=true
ProtectKernelLogs=true
RestrictRealtime=true
RestrictSUIDSGID=true
RestrictNamespaces=true

MemoryMax=512M
CPUWeight=100
IOWeight=10
TasksMax=50

[Install]
WantedBy=multi-user.target
```

Figure 6 Deno Systemd Servie

c. Fail2ban

Afterwards, we configured Fail2Ban to further secure SSH by banning IP addresses for one hour if they fail authentication five times within a 10-minute window..

```
#!/usr/bin/bash

set -e

echo "=== Installing fail2ban ==="
sudo apt update
sudo apt install -y fail2ban

echo "=== Enabling and starting fail2ban ==="
sudo systemctl enable --now fail2ban

SCRIPT_DIR="$(cd "$(dirname "${BASH_SOURCE[0]}")" && pwd)"

echo "=== Copying jail.local (SSH config) ==="
sudo cp "$SCRIPT_DIR/jail.local" /etc/fail2ban/jail.local

echo "=== Restarting fail2ban ==="
sudo systemctl restart fail2ban
sleep 5
echo "=== Checking fail2ban status ==="
sudo fail2ban-client status sshd ||
  echo "SSH jail not active yet - check log"

echo "=== Done ==="
```

Figure 7 Fail2Ban script

This script installs Fail2Ban, enables its service, and copies the configuration file to the correct /etc/fail2ban/ directory. It then restarts the service and prints its status. The configuration is straightforward: it sets the port to ssh, the filter to sshd, specifies the log path, and defines the maximum number of retries, the time window, and the ban duration.

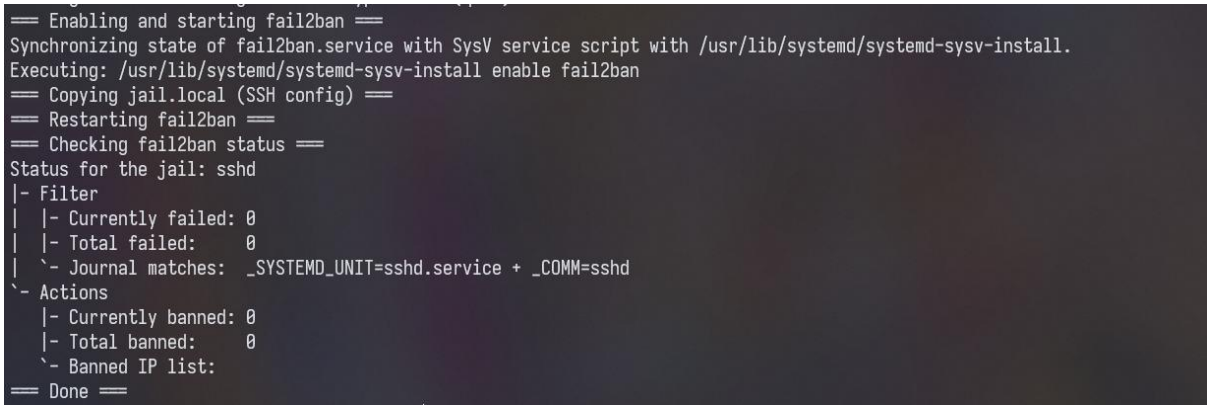


Figure 8 Fail2Ban Status

d. Ubuntu Pro and unattended-upgrades

We chose to enable and configure the unattended-upgrades as a way to automatically receive and install software and security updates from the Ubuntu repositories. First, we created a script which takes the token needed to authenticate our machine with the Ubuntu Pro service to verify that we have a valid license as it is aimed at business customers. They do provide the first 5 machines free of charge tho, so we took advantage of this to have access to the additional ESM (Expanded Security Maintenance) Repositories which provide LTS support for security updates.

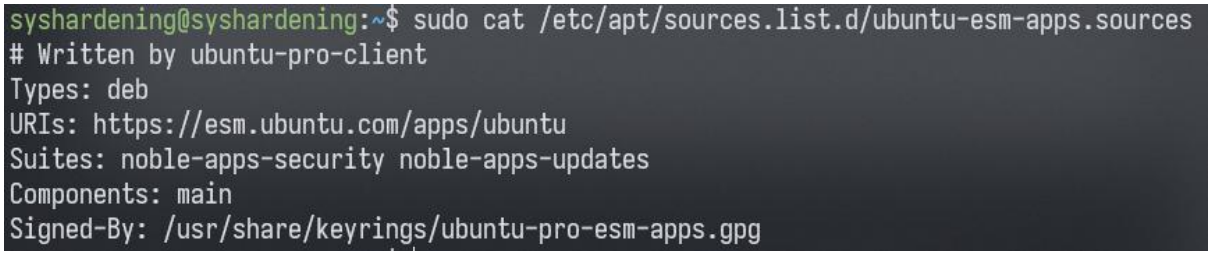


Figure 9 APT Sources Config

Above is a picture of one of those sources which got automatically added by the ubuntu pro client. We used a shell-script to enable and apply various features offered by it. The one we didn't enable was the Ubuntu Security Guide as it was redundant due to our use of Lynis to validate configurations and the defaults seemed way too strict as it tried to remove Nginx multiple times even after directly specifying that we wanted to set the server up as a webserver.

```
# Enable security features (excluding usg)
SECURITY_FEATURES=(
    esm-infra
    esm-apps
    livepatch
    fips
    fips-updates
    cis
    kernel-livepatch
)

for feature in "${SECURITY_FEATURES[@]}"; do
    if pro status | grep -q "$feature.*disabled"; then
        echo "Enabling $feature..."
        sudo pro enable "$feature"
    else
        echo "$feature already enabled or not available."
    fi
done

echo "Ubuntu Pro attached and security features enabled."
```

Figure 10 Ubuntu Pro Features

This is a part from the above-mentioned script which just enables all features from the list above.

```
syshardening@syshardening:~$ pro status
SERVICE          ENTITLED  STATUS       DESCRIPTION
anbox-cloud      yes       disabled     Scalable Android in the cloud
esm-apps         yes       enabled      Expanded Security Maintenance for Applications
esm-infra        yes       enabled      Expanded Security Maintenance for Infrastructure
landscape        yes       disabled     Management and administration tool for Ubuntu
livepatch        yes       enabled      Canonical Livepatch service
realtime-kernel* yes       disabled     Ubuntu kernel with PREEMPT_RT patches integrated
usg              yes       disabled     Security compliance and audit tools
```

Figure 11 Ubuntu Pro Client

The next step was to configure the unattended-upgrades service to run once a day and install both security- and normal feature-updates. We decided to also restart the server if an update required it as for our case the added security benefits outweigh the short downtime from a reboot.

There are two configuration files which decide how the service runs.

The first enables parts of the service and the second decides when and which upgrades are installed.

```
APT::Periodic::Update-Package-Lists 1;
APT::Periodic::Download-Upgradeable-Packages 1;
APT::Periodic::AutocleanInterval 7;
APT::Periodic::Unattended-Upgrade 1;
```

Figure 12 20auto-updates

The options here tell the service to update the local package database first before checking for outdated software and set it to clean that cache every 7 days.

```
Unattended-Upgrade::Allowed-Origins {
        "Ubuntu:noble-security";
        "Ubuntu:noble-updates";
};

Unattended-Upgrade::Package-Blacklist {
};

Unattended-Upgrade::Automatic-Reboot true;
Unattended-Upgrade::Automatic-Reboot-Time "02:00";
```

Figure 13 50unattended-upgrades

The second one here specifies which repositories we want to use for the updates and the time for the reboot.

The script for enabling the service copies those two files from templates to the correct location and afterwards installs the service via apt which starts the service in the process.

e. Nginx and certbot using Let's Encrypt

We chose to use Nginx as a reverse proxy to securely expose our Deno Todo App to the internet. It is a popular and well-documented web server acting as our reverse proxy. With Nginx we can allow to route traffic to our local Deno server, apply security headers, enforce HTTPS and filter requests. Certbot automates the process of requesting and renewing TLS certificates from Let's Encrypt, which helps us keeping our connection secure with minimal manual work. We made a shell script to automatically install Nginx and certbot, obtain a TLS certificate from Let's encrypt and copy the Nginx config to their specified directories, lastly restarting Nginx itself.

```
echo "[+] Requesting certificate using TLS-ALPN-01..."
sudo certbot certonly \
  --nginx \
  --non-interactive \
  --agree-tos \
  -m "$EMAIL" \
  -d "$DOMAIN"

echo "[+] Backing up original NGINX config..."
sudo cp "$NGINX_CONF_DST" "$NGINX_CONF_BACKUP"

echo "[+] Replacing global NGINX config with hardened version..."
sudo cp "$NGINX_CONF_SRC" "$NGINX_CONF_DST"

echo "[+] Deploying site config for application..."
sudo cp "$NGINX_SITE_CONF_SRC" "$NGINX_SITE_CONF_DST"
sudo ln -sf "$NGINX_SITE_CONF_DST" "$NGINX_ENABLED_LINK"

echo "[+] Testing and restarting NGINX with new configuration..."
sudo nginx -t
sudo systemctl start nginx
```

Figure 14 Nginx Script

We configured Nginx to redirect all HTTP traffic to HTTPS, and setup SSL with the needed certificate and resolver. It also includes modern TLS protocols (v1.2 and v.1.3), only strong cipher suites and security headers such as HSTS and X-Frame-options. We also added request rate limits, allow only GET, POST, HEAD and DELETE methods, and deny access to hidden files. Lastly, we have the actual reverse Proxy, by setting the URI of the Deno web application. Below are some screenshots of the configuration for the Deno web application.

```
# Redirect HTTP to HTTPS
server {
    listen 80;
    server_name syshardening.lampart.dev;

    location / {
        return 301 https://$host$request_uri;
    }
}
```

Figure 15 Nginx - HTTP Redirect

```
# HTTPS reverse proxy
server {
    listen 443 ssl http2;
    server_name syshardening.lampart.dev;

    ssl_certificate /etc/letsencrypt/live/syshardening.lampart.dev/fullchain.pem;
    ssl_certificate_key /etc/letsencrypt/live/syshardening.lampart.dev/privkey.pem;

    ssl_protocols TLSv1.2 TLSv1.3;
    ssl_ciphers 'ECDHE-ECDSA-AES256-GCM-SHA384:ECDHE-RSA-AES256-GCM-SHA384';
    ssl_prefer_server_ciphers on;
    ssl_session_cache shared:SSL:10m;
    ssl_session_timeout 10m;
    ssl_stapling on;
    ssl_stapling_verify on;
    resolver 1.1.1.1 1.0.0.1 valid=300s;
    resolver_timeout 5s;
```

Figure 16 Nginx SSL

```
    # Rate limiting
    limit_req zone=api burst=20 nodelay;

    # Only allow GET/POST/HEAD/DELETE methods
    if ($request_method !~ ^(GET|POST|HEAD|DELETE)$) {
        return 405;
    }

    # Deny hidden files
    location ~ /\. {
        deny all;
    }
```

Figure 17 Nginx Rate Limit

```
# Reverse proxy to Deno app
location / {
    proxy_pass http://localhost:8000;
    proxy_http_version 1.1;
    proxy_set_header Upgrade $http_upgrade;
    proxy_set_header Connection 'upgrade';
    proxy_set_header Host $host;
    proxy_cache_bypass $http_upgrade;
}
```

Figure 18 Nginx Proxy Deno

Additionally, we changed the default Nginx configuration to improve security and performance. We lowered timeout values and limited the size of requests to protect against slow or large requests. We also turned off the server version display to avoid leaking information and tweaked the TLS settings to use stronger encryption. To reduce data usage, we turned on Gzip compression, which we just uncommented from the default config. We added and error log and added basic rate limiting to prevent too many requests from one source. Finally, we adjusted buffer sizes to handle large or unusual requests more safely.

f. UFW (Uncomplicated Firewall)

For a host-firewall we decided on UFW as it is very simple to set up. We first made a list of all incoming and outgoing connections we wanted to allow and then disabled everything else. In this case that is:

Incoming

- HTTP
- HTTPS
- SSH

Outgoing

- HTTP
- HTTPS
- DNS
- NTP

We also enabled logging for all traffic so we would have the ability to later monitor the traffic for anomalies.

```
syshardening@syshardening:~$ sudo ufw status verbose
Status: active
Logging: on (low)
Default: deny (incoming), deny (outgoing), disabled (routed)
New profiles: skip

To                         Action      From
--                         ------      ----
22/tcp                     ALLOW IN    Anywhere
80/tcp                     ALLOW IN    Anywhere
443/tcp                    ALLOW IN    Anywhere
22/tcp (v6)                ALLOW IN    Anywhere (v6)
80/tcp (v6)                ALLOW IN    Anywhere (v6)
443/tcp (v6)               ALLOW IN    Anywhere (v6)

53                         ALLOW OUT   Anywhere
80                         ALLOW OUT   Anywhere
443                        ALLOW OUT   Anywhere
123/udp                    ALLOW OUT   Anywhere
53 (v6)                    ALLOW OUT   Anywhere (v6)
80 (v6)                    ALLOW OUT   Anywhere (v6)
443 (v6)                   ALLOW OUT   Anywhere (v6)
123/udp (v6)               ALLOW OUT   Anywhere (v6)
```

Figure 19 UFW - Status

Below is a randomly selected section of the ufw.log which shows attempted connections to our server which were blocked by the Firewall. Those are most likely from systems trying to scan servers for open ports or similar.

```
2025-06-02T16:39:33.434783+00:00 syshardening kernel: [UFW BLOCK] IN=eth0 OUT= MAC=96:
00:04:54:94:8d:d2:74:7f:6e:37:e3:08:00 SRC=79.124.62.134 DST=65.109.163.81 LEN=40 TOS=
0x00 PREC=0x00 TTL=242 ID=12726 PROTO=TCP SPT=0 DPT=18458 WINDOW=1024 RES=0x00 SYN URG
P=0
2025-06-02T16:39:36.954621+00:00 syshardening kernel: [UFW BLOCK] IN=eth0 OUT= MAC=96:
00:04:54:94:8d:d2:74:7f:6e:37:e3:08:00 SRC=195.82.147.152 DST=65.109.163.81 LEN=44 TOS
=0x00 PREC=0x00 TTL=248 ID=63446 PROTO=TCP SPT=58451 DPT=1080 WINDOW=1025 RES=0x00 SYN
 URGP=0
2025-06-02T16:40:01.861583+00:00 syshardening kernel: [UFW BLOCK] IN=eth0 OUT= MAC=96:
00:04:54:94:8d:d2:74:7f:6e:37:e3:08:00 SRC=179.43.191.98 DST=65.109.163.81 LEN=40 TOS=
0x00 PREC=0xA0 TTL=243 ID=54321 PROTO=TCP SPT=59216 DPT=34568 WINDOW=65535 RES=0x00 SY
N URGP=0
2025-06-02T16:40:18.203891+00:00 syshardening kernel: [UFW BLOCK] IN=eth0 OUT= MAC=96:
00:04:54:94:8d:d2:74:7f:6e:37:e3:08:00 SRC=134.209.173.54 DST=65.109.163.81 LEN=52 TOS
=0x00 PREC=0x00 TTL=50 ID=15376 PROTO=TCP SPT=36846 DPT=21297 WINDOW=65535 RES=0x00 SY
N URGP=0
```

Figure 20 UFW - Log

g. Aide and auditd

Aide (Advanced Intrusion Detection Environment) is software by Red Hat which checks the integrity of files and directories against a internal database. This enables us to create that database after setting up the server to ensure that any changes to the configuration, done either by updates or a potentially malicious 3rd party are immediately visible. This is done via a cronjob which is run daily, that then prints out the results into a logfile.

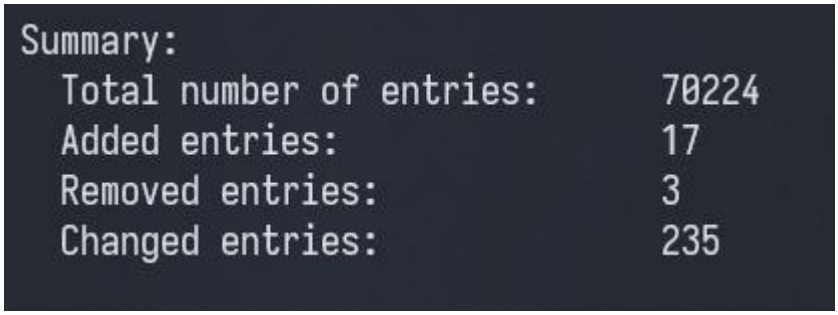


Figure 21 Aide - Changes

Here, for example, we installed some software and edited some files so the system would be able to find differences to allow us to test the system.

Above is the overview of all changes to files monitored by the system.

Below that in the log we are given a table-view of all edited, deleted or modified files and directories. Here for example the newly added ones.

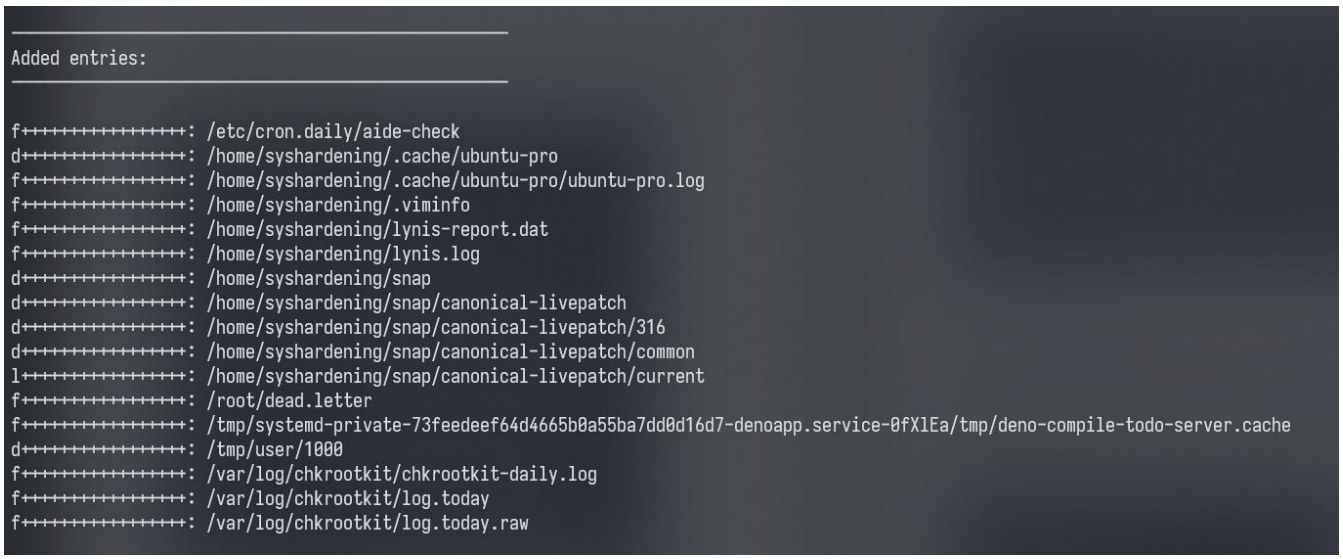


Figure 22 Aide - Added files

This is the shell-script we created to automate the deployment of aide to the machine for us.

```
#!/usr/bin/bash

set -e

echo "[*] Installing AIDE..."
sudo apt update
sudo apt install -y aide

AIDE_CONF="/etc/aide/aide.conf"

echo "[+] Backing up current aide.conf to aide.conf.bak"
sudo cp "$AIDE_CONF" "${AIDE_CONF}.bak"

echo "[+] Updating Checksums line to use sha512"      You, 5 hours ago • more hardening
sudo sed -i -r 's/^Checksums\s*=.*/Checksums = sha512/' "$AIDE_CONF"

echo "[*] Initializing AIDE database..."
sudo aideinit

echo "[*] Replacing the default database with the initialized one..."
sudo cp /var/lib/aide/aide.db.new /var/lib/aide/aide.db

echo "[*] Creating a daily cron job to check system integrity..."
cat << 'EOF' | sudo tee /etc/cron.daily/aide-check > /dev/null
#!/usr/bin/bash
# AIDE daily check script

LOGFILE="/var/log/aide/aide-check.log"
mkdir -p "$(dirname "$LOGFILE")"

echo "[*] Running AIDE integrity check on $(date)" >> "$LOGFILE"
aide --check --config /etc/aide/aide.conf >> "$LOGFILE"
EOF

sudo chmod +x /etc/cron.daily/aide-check

echo "[*] Configuration complete. AIDE will now check file integrity daily."
```

Figure 23 Aide – ShellScript

It starts out with installing aide via apt. We make a change to the default configuration with the software to use the more secure sha512 hashing algorithm but leave it default aside from that. Afterwards we initialize a new database on the system which takes a while as it will calculate the hash for each file on the system, aside from exceptions like temporary files. Then we take the resulting file and overwrite the existing (empty) database. The last step creates a cronjob to check the database against our server daily and saves the results.

In addition to aide we are also using auditd to monitor various other events happening on the machine. For example, executed commands, attempts at modifying files or privilege escalation. For this we wrote and collected some rules we deemed useful.

Those are stored in a separate file next to a script to install auditd and apply them which makes it really easy to change or update them. The hardest part of setting this up was debating on which sources, be it files, folders or interrupts sent from the auditd kernel module to monitor. Below are some examples and why we chose them.

```
# Monitor user/group changes
-w /etc/group -p wa -k group_changes
-w /etc/gshadow -p wa -k gshadow_changes

# Monitor sudo commands
-w /var/log/sudo.log -p rwxa -k sudo_log

# Monitor nginx configuration changes
-w /etc/nginx/ -p wa -k nginx_conf
```

Figure 24 auditd - rules user

The above rules monitor for changes to users and groups as that should practically never happen after the system is fully configured. Additionally in this snippet we are watching the sudo.log to see which commands are executed that way and the last part ensures that the configuration for our Nginx setup is not altered in any way.

```
# Network Configuration
-w /etc/network/interfaces -p wa -k network_config
-w /etc/netplan/ -p wa -k netplan_config
-w /etc/ufw/ -p wa -k ufw_config
```

Figure 25 auditd - rules network

This part checks for changes regarding network changes, either to the firewall or network setup via netplan.

```
# 3. User Activity and Authentication
# Login/Logout Events (additional to syslog)
-w /var/log/faillog -p wa -k login_failure
-w /var/log/lastlog -p wa -k lastlog_update
-w /var/log/tallylog -p wa -k login_tally

# User and Group Modification Tools
-w /usr/sbin/useradd -p x -k user_add
-w /usr/sbin/usermod -p x -k user_mod
-w /usr/sbin/userdel -p x -k user_del
-w /usr/sbin/groupadd -p x -k group_add
-w /usr/sbin/groupmod -p x -k group_mod
-w /usr/sbin/groupdel -p x -k group_del
-w /usr/bin/passwd -p x -k passwd_cmd
```

Figure 26 auditd - rules auth

Here we watch for the use of tools which modify users in any way like changing a password or adding a user, additionally it sees every failed login via the logs above.

```
# Monitor /etc/passwd and /etc/shadow for changes
-w /etc/passwd -p wa -k passwd_changes
-w /etc/shadow -p wa -k shadow_changes
```

Figure 27 auditd - rules passwords

This part also watches for password/user changes but in a more direct way by monitoring the /etc/passwd and shadow file

```
# 4. Important Directories
# /var/log/ - Monitor for log tampering
-w /var/log/audit/ -p wa -k audit_log_changes
-w /var/log/apt/ -p wa -k apt_log_changes
-w /var/log/auth.log -p wa -k auth_log_changes

# /boot/ - Changes to boot loader or kernel images
-w /boot/ -p wa -k boot_changes

# /opt/ and /srv/ - Application/service directories
-w /opt/ -p wa -k opt_dir_changes
-w /srv/ -p wa -k srv_dir_changes
```

Figure 28 auditd - rules important files

This last part watches important directories and files like the auth.log but also the /opt folder in which our Deno-App and database are located.

The reports can be searched and viewed by included tools like ausearch and aureport

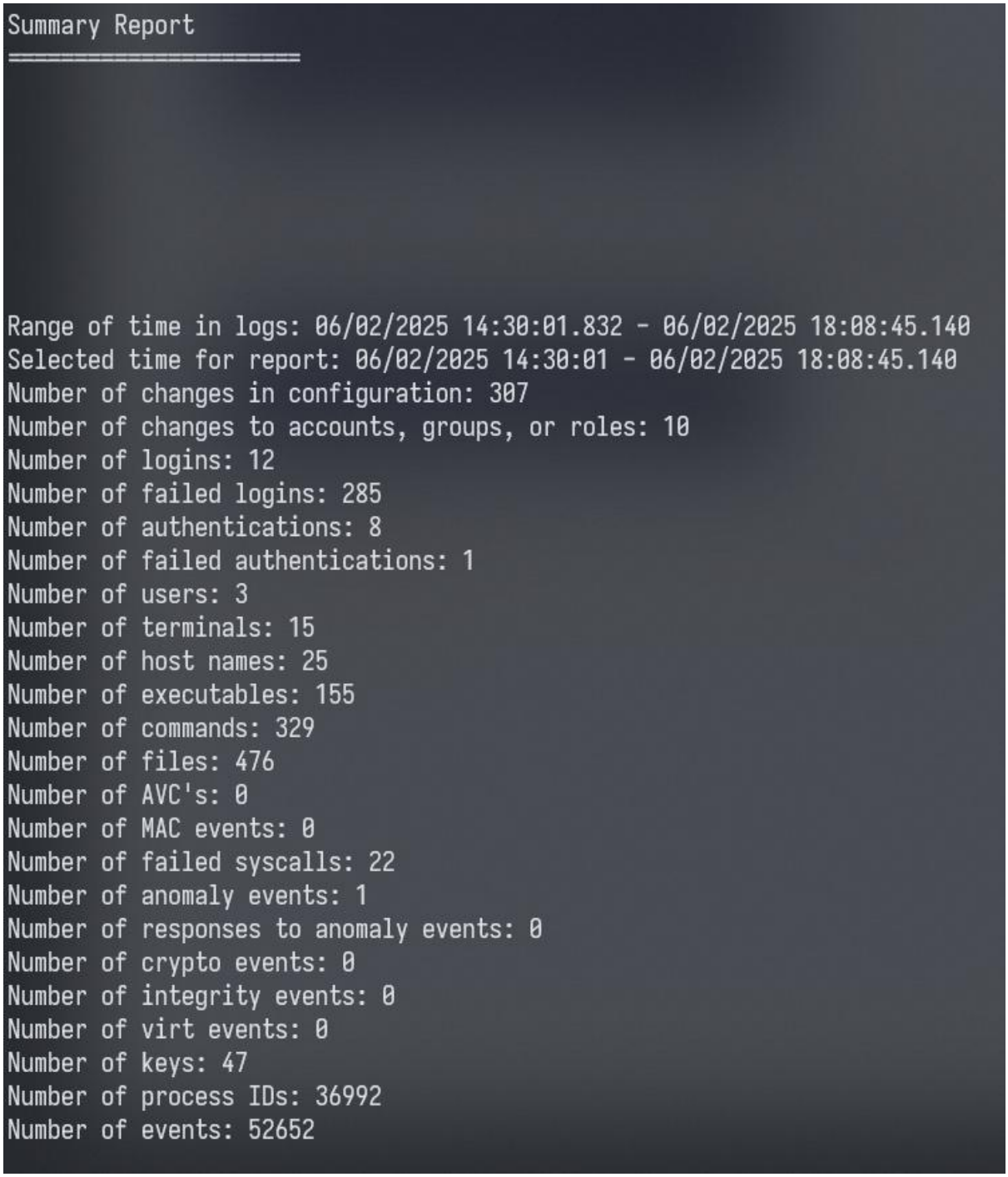


Figure 29 auditd - report

Here is an example of using “aureport -i” to see the whole report of all logged activities since the start of the software.

Or here using “ausearch -i -k sudo_log” to only show the usage of sudo (this is only one entry)

```
syshardening@syshardening:~$ sudo ausearch -i -k sudo_log
Skipping line 42 in /etc/audit/auditd.conf: too long
----
type=PROCTITLE msg=audit(06/02/2025 14:30:05.464:281) : proctitle=/sbin/auditctl -R /e
tc/audit/audit.rules
type=PATH msg=audit(06/02/2025 14:30:05.464:281) : item=0 name=/var/log/ inode=50 dev=
08:01 mode=dir,775 ouid=root ogid=syslog rdev=00:00 nametype=PARENT cap_fp=none cap_fi
=none cap_fe=0 cap_fver=0 cap_frootid=0
type=CWD msg=audit(06/02/2025 14:30:05.464:281) : cwd=/home/syshardening/syshardening
type=SOCKADDR msg=audit(06/02/2025 14:30:05.464:281) : saddr={ saddr_fam=netlink nlnk-
fam=16 nlnk-pid=0 }
type=SYSCALL msg=audit(06/02/2025 14:30:05.464:281) : arch=x86_64 syscall=sendto succe
ss=yes exit=1084 a0=0x3 a1=0x7ffdcb8deca0 a2=0x43c a3=0x0 items=1 ppid=4336 pid=4350 a
uid=syshardening uid=root gid=root euid=root suid=root fsuid=root egid=root sgid=root
fsgid=root tty=pts2 ses=1 comm=auditctl exe=/usr/sbin/auditctl subj=unconfined key=(nu
ll)
type=CONFIG_CHANGE msg=audit(06/02/2025 14:30:05.464:281) : auid=syshardening ses=1 su
bj=unconfined op=add_rule key=sudo_log list=exit res=yes
----
```

Figure 30 auditd – search

h. General Hardening

This chapter is for everything that didn't fit into any of the other categories/software. Most of those are based on recommendations from Lynis or the Moodle course. First, we edited various kernel parameters based on the feedback that Lynis gave:

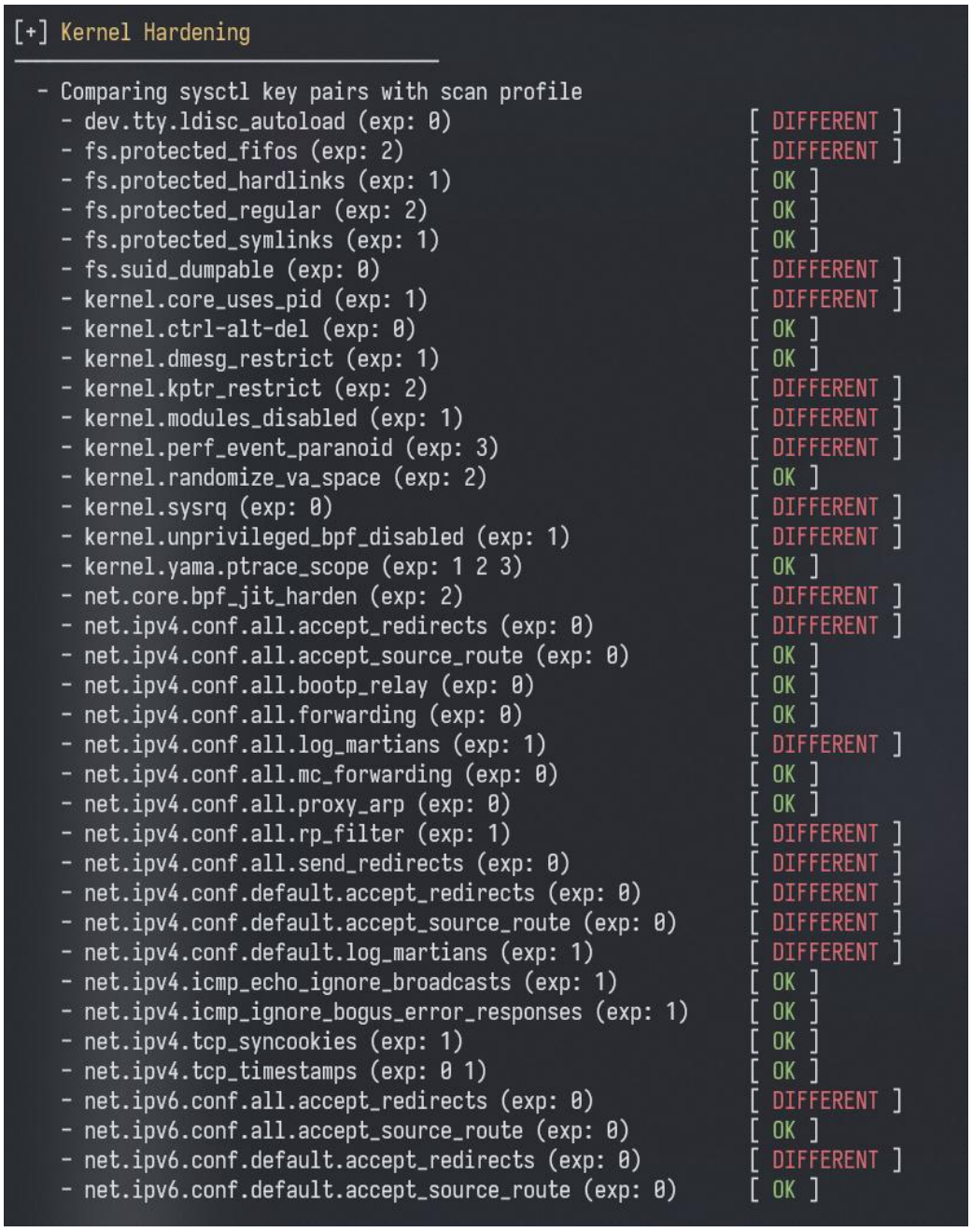


Figure 31 Lynis Kernel

Some of those are to protect symlinks and hard-links, "kernel.suid_dumpable" prevents kernel dumps when an elevated program crashes. Most of the others are meant for preventing various network-based attacks like man-in-the-middle attacks. The one rule

we did not enable was “kernel.modules_disabled” which interfered with auditd and other modules which were not correctly loaded anymore.

```
dev.tty.ldisc_autoload = 0
fs.protected_fifos = 2
fs.suid_dumpable = 0
kernel.core_uses_pid = 1
kernel.kptr_restrict = 2
kernel.perf_event_paranoid = 3
kernel.sysrq = 0
kernel.unprivileged_bpf_disabled = 1
net.core.bpf_jit_harden = 2
net.ipv4.conf.all.log_martians = 1
net.ipv4.conf.all.rp_filter = 1
net.ipv4.conf.all.send_redirects = 0
net.ipv4.conf.default.accept_source_route = 0
net.ipv4.conf.default.log_martians = 1
```

Figure 32 General Hardening Rule Override

The overrides are stored in a separate file which then gets copied into /etc/sysctl.d/ and applied via “sysctl --system”.

Next, we tightened the permission on various folders and files as the defaults set by Ubuntu were not ideal for everything. Below a snippet from the script which applies all the changes in this category

```
echo "[+] Securing file and cron permissions"

sudo chmod 600 /etc/at.deny /etc/crontab /etc/ssh/sshd_config
sudo chown root:root /etc/at.deny /etc/crontab /etc/ssh/sshd_config

for dir in /etc/cron.d /etc/cron.daily /etc/cron.hourly /etc/cron.weekly /etc/cron.monthly; do
    sudo chmod 700 "$dir"
    sudo chown root:root "$dir"
done
```

Figure 33 General Hardening Files

Another small thing was changing /etc/issue and /etc/issue.net to not show the OS version by overwriting them with a disclaimer.

```
echo "[+] Setting hardened login banners"
BANNER_TEXT="Authorized access only. Unauthorized use is prohibited and will be prosecuted."
echo "$BANNER_TEXT" | sudo tee /etc/issue /etc/issue.net > /dev/null      You, 6 hours ago • m
```

Figure 34 General Hardening Banner

After that we installed chkrootkit to monitor the server daily for signs of a rootkit similar software. As there is not really anything to configure, we just installed it via our script

and set up a cronjob with logging for it. When we checked the logs the only thing it found was a false-positive for system-networkd.

```
Checking `sniffer'...                                    WARNING

WARNING: Output from ifpromisc:
lo: not promisc and no packet sniffer sockets
eth0: PACKET SNIFFER(/usr/lib/systemd/systemd-networkd[824])
```

Figure 35 General Hardening chkrootkit

The next step was to disable certain unused network protocols as suggested by Lynis, which was done by disabling associated kernel-modules and rebuilding the initramfs

```
echo "[+] Blacklisting unused protocols (dccp, sctp, rds, tipc)"
cat <<EOF | sudo tee /etc/modprobe.d/disable-unused-protocols.conf >/dev/null
blacklist dccp
blacklist sctp
blacklist rds
blacklist tipc
EOF

sudo update-initramfs -u
```

Figure 36 General Hardening Initramfs

The last things were installing auditing tools like acct which monitors user activity on the system and changing the default umask from 022 to 027 to better isolate the files from one user to another. This obviously only applies to new files, but we still wanted to include it as an easy fix that could help prevent a user reading a file that they shouldn't. The last thing we did was set a timeout for inactive users via the TMOUT variable in the profile file.

3. Conclusion

Overall, we found a lot of different configuration options and tools that helped us harden our server setup. One major advantage was that we weren't starting from scratch—there are many resources and examples online from others who have built similar systems. This made it a lot easier to figure out what we could change or install to improve security. Of course, there's always more that could be done. For example, setting up a SIEM or XDR system like Wazuh would add another layer of protection, but it would also require a separate server and was beyond the scope of this exercise.

Our main goal was to securely deploy a Deno-based web application and make it accessible over the internet via HTTPS. Based on the steps we followed, we believe we've reached a solid level of security for both the Deno app and the Ubuntu 24.04 virtual machine it runs on.

In conclusion, we were able to create a secure environment for our Deno web app. By taking a layered security approach—covering everything from the host system and network to the application itself—we were able to reduce the risk of common attacks. Using a mix of automation tools and manual configurations helped us build a system that's not only secure but also well-monitored and ready to be used in a real-world internet-facing setup.

All the configuration files and scripts and other files (including this Document) are stored in a public Git Repository on GitHub: https://github.com/icefishii/syshardening

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5. Images