Lab 5 Report: Securing Apache Web Server with SSL/TLS

Objective

To setup a secure web server using Apache and digital certificates, implementing HTTPS protocol with SSL/TLS encryption for secure communication.

What is PEM File?

PEM (Privacy-Enhanced Mail) Format:

PEM is a **base64 encoded format** for storing certificates and keys. It's the most common format used in web servers.

PEM File Structure:

text

```
-----BEGIN PRIVATE KEY-----

[Base64 encoded private key]

-----END PRIVATE KEY-----

-----BEGIN CERTIFICATE-----

[Base64 encoded certificate]

-----END CERTIFICATE-----
```

Why We Need PEM File:

- **Combines private key and certificate** in one file
- **Apache and OpenSSL** can easily read this format
- **Simplifies configuration** - single file reference
- **Standard format** for web servers

Task-1: Becoming a Certificate Authority (CA)

Steps Performed:

1.1 Directory Structure Setup

bash

```
mkdir lab5_ssl

cd lab5_ssl

cp /usr/lib/ssl/openssl.cnf .

mkdir -p demoCA/{certs,crl,newcerts,private}

touch demoCA/index.txt

echo "1000" > demoCA/serial
```

1.2 CA Certificate Generation

bash

```
openssl req -new -x509 -keyout ca.key -out ca.crt -config openssl.cnf
```

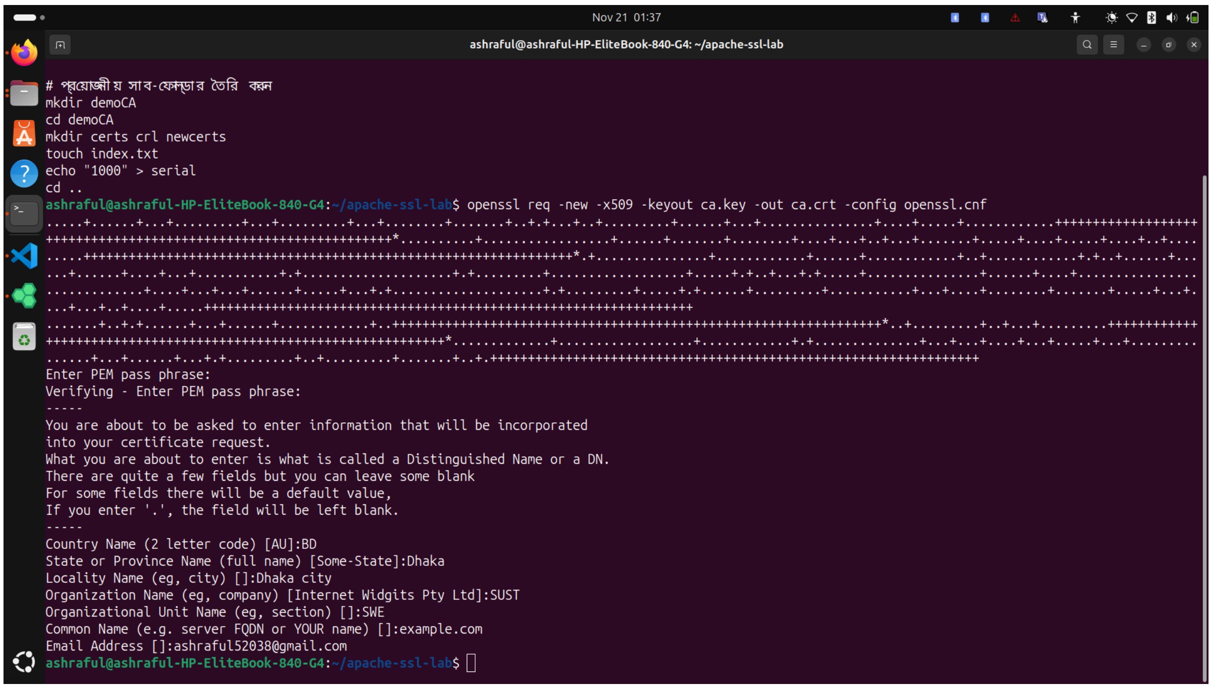
Information Provided:

- Country Name: BD
- State: Dhaka
- Locality: Dhaka City
- Organization: SUST
- Common Name: Ashraful (My Own CA)

1.3 Files Created:

- `ca.key` - CA private key (encrypted)

- `ca.crt` - CA public certificate



```
# প্রয়োজনীয় সাব-ফোল্ডার তৈরি করুন
mkdir demoCA
cd demoCA
mkdir certs crl newcerts
touch index.txt
echo "1000" > serial
cd ..
ashraful@ashraful-HP-EliteBook-840-G4:~/apache-ssl-lab$ openssl req -new -x509 -keyout ca.key -out ca.crt -config openssl.cnf
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Enter PEM pass phrase:
Verifying - Enter PEM pass phrase:
-----
You are about to be asked to enter information that will be incorporated
into your certificate request.
What you are about to enter is what is called a Distinguished Name or a DN.
There are quite a few fields but you can leave some blank
For some fields there will be a default value,
If you enter '.', the field will be left blank.
-----
Country Name (2 letter code) [AU]:BD
State or Province Name (full name) [Some-State]:Dhaka
Locality Name (eg, city) []:Dhaka city
Organization Name (eg, company) [Internet Widgits Pty Ltd]:SUST
Organizational Unit Name (eg, section) []:SWE
Common Name (e.g. server FQDN or YOUR name) []:example.com
Email Address []:ashraful52038@gmail.com
ashraful@ashraful-HP-EliteBook-840-G4:~/apache-ssl-lab$
```

Task-2: Creating Certificate for example.com

Steps Performed:

2.1 Server Key Generation

bash

openssl genrsa -des3 -out server.key 2048

2.2 Certificate Signing Request (CSR)

bash

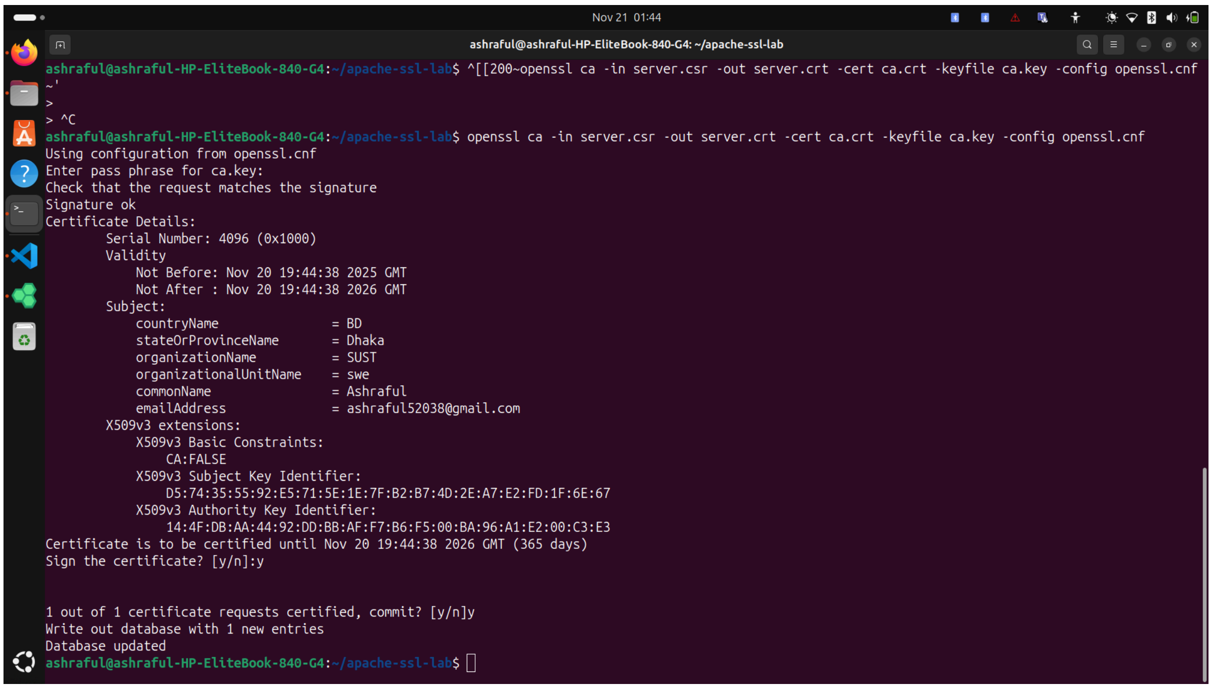
openssl req -new -key server.key -out server.csr -config openssl.cnf

Common Name: example.com (critical for domain validation)

2.3 Certificate Signing

bash

openssl ca -in server.csr -out server.crt -cert ca.crt -keyfile ca.key -config openssl.cnf



```
ashraful@ashraful-HP-EliteBook-840-G4:~/apache-ssl-lab$ ^[[200~openssl ca -in server.csr -out server.crt -cert ca.crt -keyfile ca.key -config openssl.cnf
~'
>
> ^C
ashraful@ashraful-HP-EliteBook-840-G4:~/apache-ssl-lab$ openssl ca -in server.csr -out server.crt -cert ca.crt -keyfile ca.key -config openssl.cnf
Using configuration from openssl.cnf
Enter pass phrase for ca.key:
Check that the request matches the signature
Signature ok
Certificate Details:
        Serial Number: 4096 (0x1000)
        Validity
            Not Before: Nov 20 19:44:38 2025 GMT
            Not After : Nov 20 19:44:38 2026 GMT
        Subject:
            countryName               = BD
            stateOrProvinceName       = Dhaka
            organizationName          = SUST
            organizationalUnitName    = swe
            commonName                = Ashraful
            emailAddress              = ashraful52038@gmail.com
        X509v3 extensions:
            X509v3 Basic Constraints:
                CA:FALSE
            X509v3 Subject Key Identifier:
                D5:74:35:55:92:E5:71:5E:1E:7F:B2:B7:4D:2E:A7:E2:FD:1F:6E:67
            X509v3 Authority Key Identifier:
                14:4F:DB:AA:44:92:DD:BB:AF:F7:B6:F5:00:BA:96:A1:E2:00:C3:E3
Certificate is to be certified until Nov 20 19:44:38 2026 GMT (365 days)
Sign the certificate? [y/n]:y


1 out of 1 certificate requests certified, commit? [y/n]y
Write out database with 1 new entries
Database updated
ashraful@ashraful-HP-EliteBook-840-G4:~/apache-ssl-lab$ 
```

2.4 PEM File Creation

bash

cp server.key server.pem

cat server.crt >> server.pem

2.5 OpenSSL HTTPS Server

bash

openssl s_server -cert server.pem -www -accept 4433

Checkpoint-1: Demonstration & Explanation

What Was Demonstrated:

Before CA Import:

- **Browser Warning:** "Potential Security Risk"
- **Error Message:** "Certificate not trusted because issuer certificate is unknown"
- **Result:** Firefox blocked connection to `https://example.com:4433`

CA Import Process:

1. Firefox Preferences → Privacy & Security → View Certificates
2. Authorities Tab → Import → Select `ca.crt`
3. Trust Settings: "Trust this CA to identify websites"
4. Certificate appears in trusted authorities list

After CA Import:

- **Successful Connection** to `https://example.com:4433`
- **Green Lock Icon** in address bar
- **OpenSSL Test Page** loaded successfully

Technical Explanation:

- **Chain of Trust:** Root CA → Server Certificate → Browser Verification
- **Initial Failure:** Our CA not in browser's pre-trusted store
- **Solution:** Manual import establishes trust relationship
- **Real-world Analog:** Commercial CAs (Verisign) pre-loaded in browsers

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Task-3: Deploying HTTPS in Apache

Steps Performed:

3.1 Enable SSL Module

bash

```
sudo a2enmod ssl
```

3.2 Apache Virtual Host Configuration

Edited `/etc/apache2/sites-available/example.com.conf`:

apache

```
<IfModule mod_ssl.c>

<VirtualHost *:443>

    ServerAdmin admin@example.com

    ServerName example.com
    ServerAlias www.example.com
    DocumentRoot /var/www/example.com/html
    ErrorLog ${APACHE_LOG_DIR}/error.log
    CustomLog ${APACHE_LOG_DIR}/access.log combined

    SSLEngine on
    SSLCertificateFile /var/www/anothervhost.com/html/lab5_ssl/server.crt
    SSLCertificateKeyFile /var/www/anothervhost.com/html/lab5_ssl/server.key
</VirtualHost>
</IfModule>
```

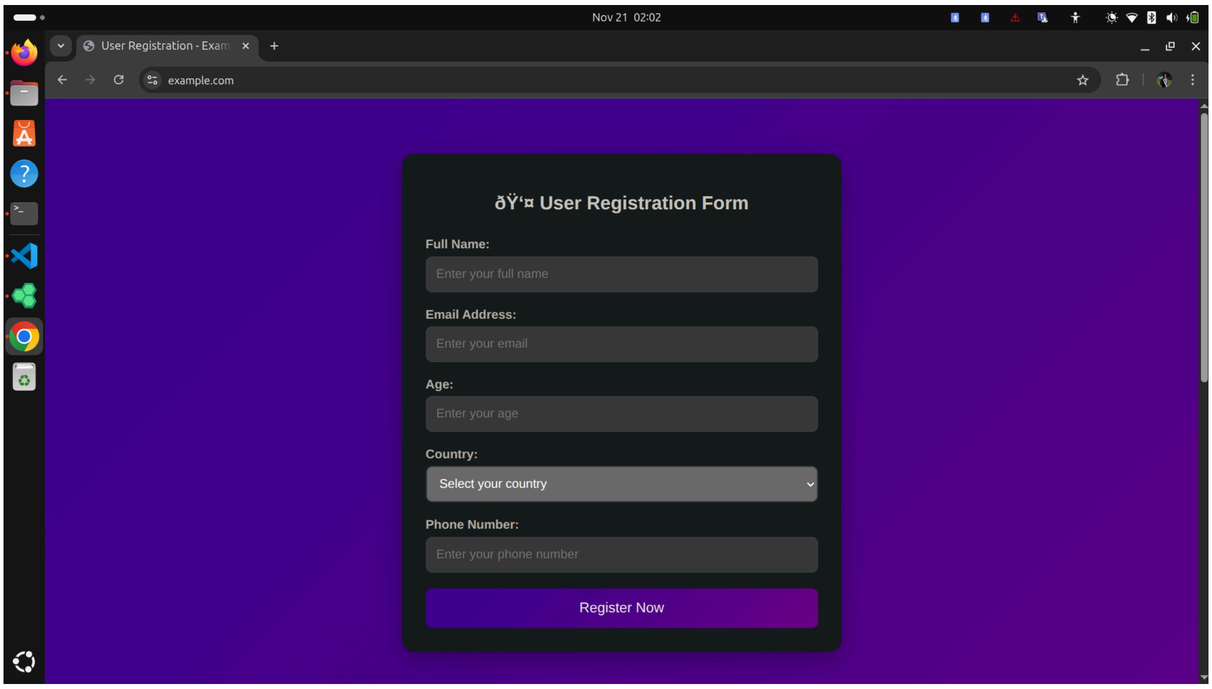
3.3 Configuration Test & Restart

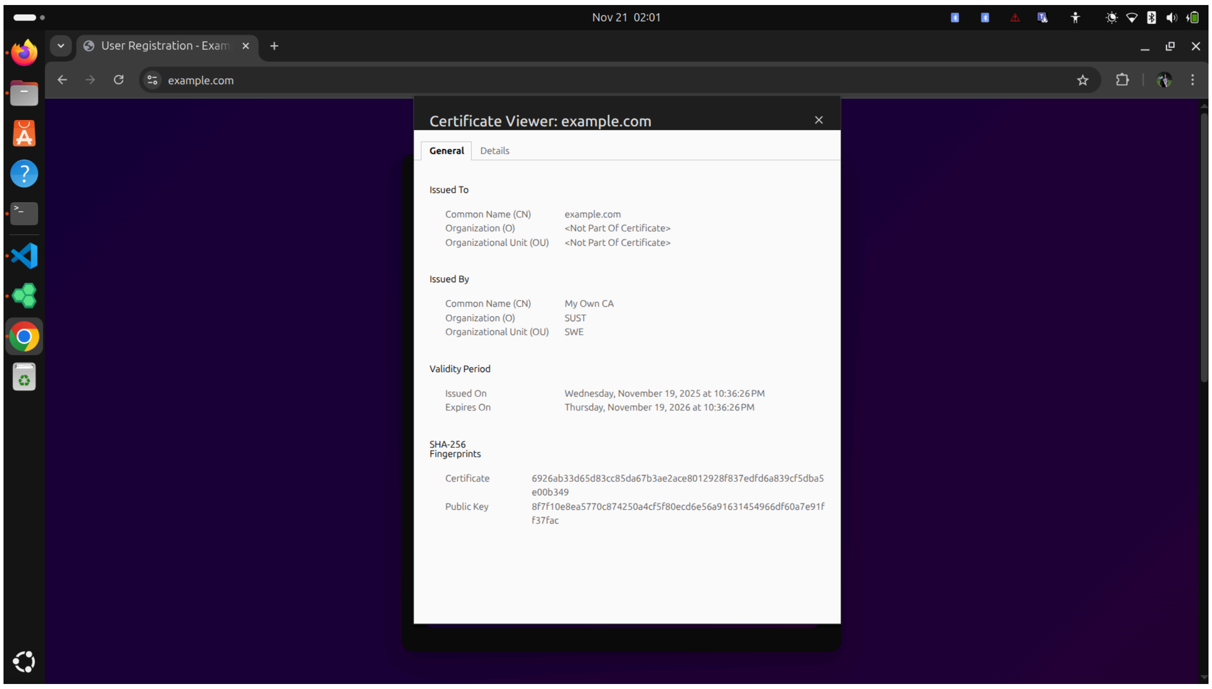
bash

```
sudo apache2ctl configtest  # Output: Syntax OK
sudo systemctl restart apache2
```

3.4 HTTPS Access

- Successfully accessed: `https://example.com`
- Green lock icon in browser
- Secure connection established

- 



Certificate Viewer: example.com

General Details

Issued To

Common Name (CN)	example.com
Organization (O)	<Not Part Of Certificate>
Organizational Unit (OU)	<Not Part Of Certificate>

Issued By

Common Name (CN)	My Own CA
Organization (O)	SUST
Organizational Unit (OU)	SWE

Validity Period

Issued On	Wednesday, November 19, 2025 at 10:36:26 PM
Expires On	Thursday, November 19, 2026 at 10:36:26 PM

SHA-256 Fingerprints

Certificate	6926ab33d65d83cc85da67b3ae2ace8012928f837edfd6a839cf5dba5e00b349
Public Key	8f7f10e8ea5770c874250a4cf5f80ecd6e56a91631454966df60a7e91ff37fac

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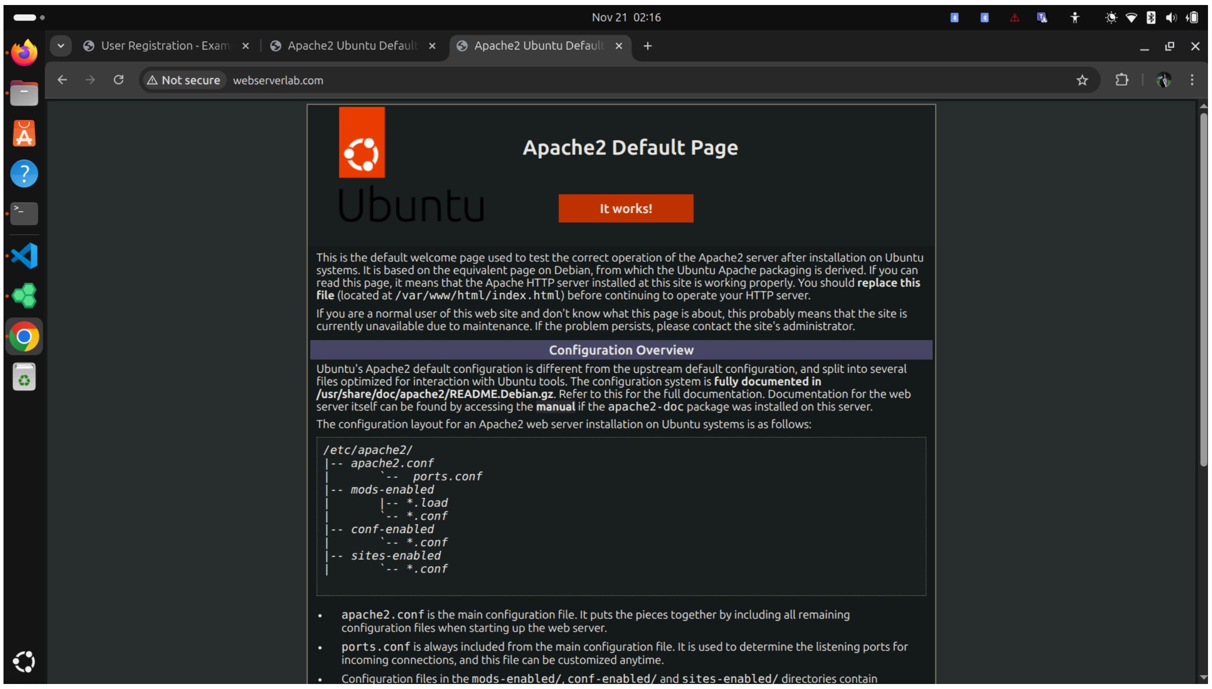
Checkpoint-2: webserverlab.com HTTPS Setup

Additional Steps:

1. Created separate certificate for webserverlab.com
2. Added SSL configuration to webserverlab.com virtual host

3. Both domains working simultaneously with HTTPS



Apache2 Default Page

It works!

This is the default welcome page used to test the correct operation of the Apache2 server after installation on Ubuntu systems. It is based on the equivalent page on Debian, from which the Ubuntu Apache packaging is derived. If you can read this page, it means that the Apache HTTP server installed at this site is working properly. You should **replace this file** (located at `/var/www/html/index.html`) before continuing to operate your HTTP server.

If you are a normal user of this web site and don't know what this page is about, this probably means that the site is currently unavailable due to maintenance. If the problem persists, please contact the site's administrator.

Configuration Overview

Ubuntu's Apache2 default configuration is different from the upstream default configuration, and split into several files optimized for interaction with Ubuntu tools. The configuration system is **fully documented in /usr/share/doc/apache2/README.Debian.gz**. Refer to this for the full documentation. Documentation for the web server itself can be found by accessing the **manual** if the `apache2-doc` package was installed on this server.

The configuration layout for an Apache2 web server installation on Ubuntu systems is as follows:

```
/etc/apache2/
|-- apache2.conf
|       `--  ports.conf
|-- mods-enabled
|       |-- *.load
|       `-- *.conf
|-- conf-enabled
|       `-- *.conf
|-- sites-enabled
|       `-- *.conf
```

- `apache2.conf` is the main configuration file. It puts the pieces together by including all remaining configuration files when starting up the web server.
- `ports.conf` is always included from the main configuration file. It is used to determine the listening ports for incoming connections, and this file can be customized anytime.
- Configuration files in the `mods-enabled/`, `conf-enabled/` and `sites-enabled/` directories contain

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Technical Concepts Learned

1. Public Key Infrastructure (PKI)

- **Certificate Authority (CA)** - Trusted entity issuing certificates
- **Digital Certificates** - Electronic documents proving identity
- **Public/Private Key Cryptography** - Asymmetric encryption

2. SSL/TLS Handshake Process

1. Client hello with supported ciphers
2. Server certificate presentation
3. Client verification of certificate
4. Session key exchange
5. Encrypted communication

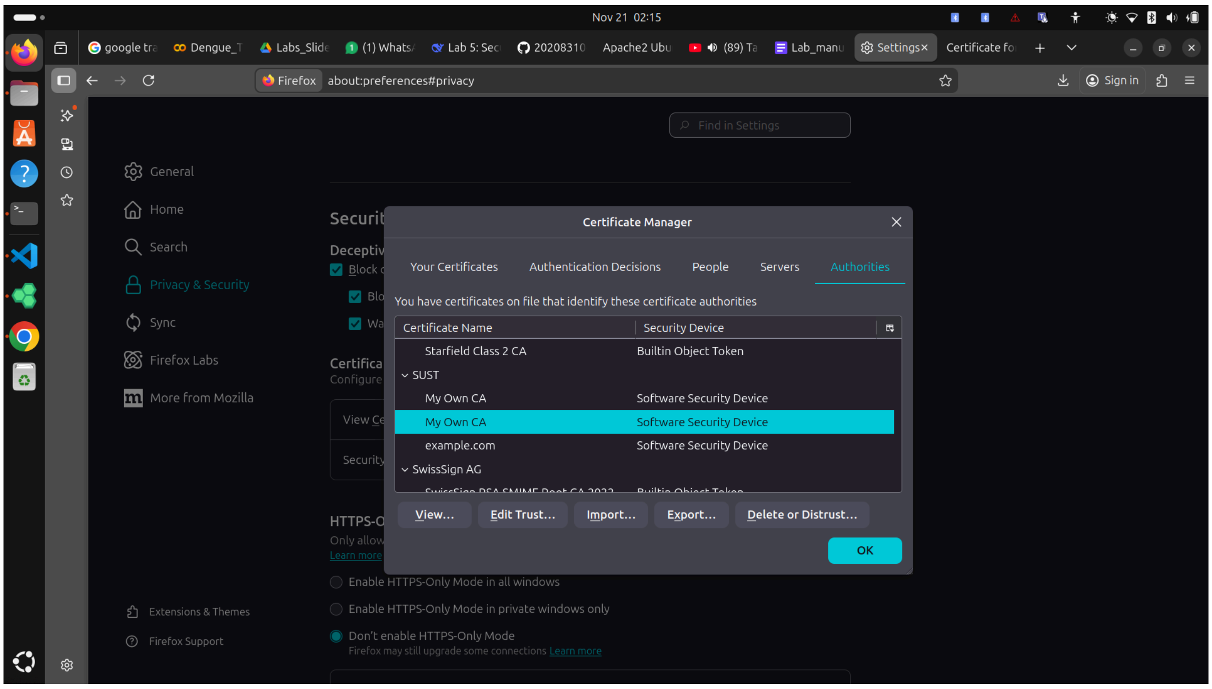
3. Certificate Types

- **Self-signed** - CA signs its own certificate (our lab CA)
- **Domain validated** - Basic domain ownership verification
- **Extended validation** - Comprehensive organization verification

4. File Formats

- **PEM** - Base64 encoded (our usage)

- **DER** - Binary format
- **PKCS#12** - Password-protected container



Certificate Manager

Your Certificates | Authentication Decisions | People | Servers | Authorities

You have certificates on file that identify these certificate authorities

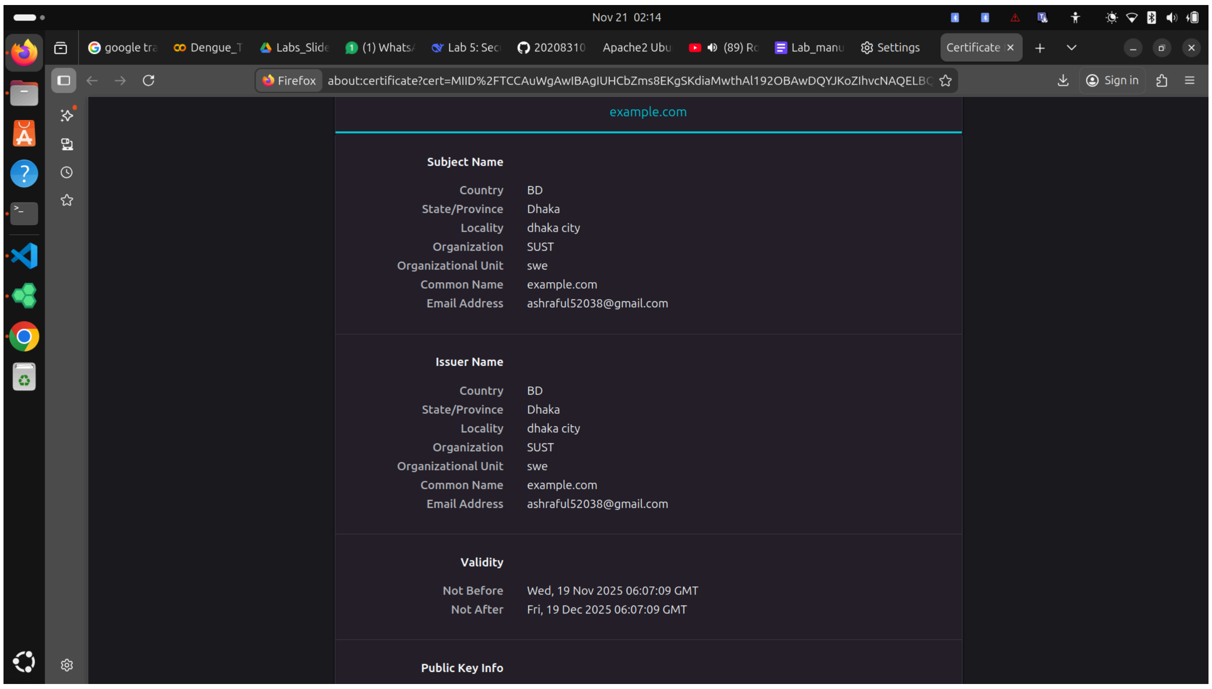
Certificate Name	Security Device
Starfield Class 2 CA	Builtin Object Token
⌄ SUST	
My Own CA	Software Security Device
My Own CA	Software Security Device
example.com	Software Security Device
⌄ SwissSign AG	

View… | Edit Trust… | Import… | Export… | Delete or Distrust… | OK

HTTPS-Only Mode

- Enable HTTPS-Only Mode in all windows
- Enable HTTPS-Only Mode in private windows only
- Don't enable HTTPS-Only Mode

Firefox may still upgrade some connections Learn more


Nov 21 02:14
Settings
Certificate
Firefox about:certificate?cert=MIID%2FTCCAuWgAwIBAgIUHCbZms8EKgSKdiaMwthAl192OBAwDQYJKoZIhvcNAQELBQ
Sign in

example.com

Subject Name

Country	BD
State/Province	Dhaka
Locality	dhaka city
Organization	SUST
Organizational Unit	swe
Common Name	example.com
Email Address	ashraful52038@gmail.com

Issuer Name

Country	BD
State/Province	Dhaka
Locality	dhaka city
Organization	SUST
Organizational Unit	swe
Common Name	example.com
Email Address	ashraful52038@gmail.com

Validity

Not Before	Wed, 19 Nov 2025 06:07:09 GMT
Not After	Fri, 19 Dec 2025 06:07:09 GMT

Public Key Info

Security Implementation Results

Successful Deployments:

✅ example.com - HTTPS enabled with valid certificate
✅ webserverlab.com - HTTPS enabled with valid certificate
✅ **Apache SSL Module** - Properly configured and running
✅ **Browser Trust** - CA certificate imported and trusted

Encryption Indicators:

- 🔒 **Green lock icon** in browser address bar
- 📜 **Valid certificate** details accessible
- 🌐 **HTTPS protocol** in URL
- ✅ **"Connection is secure"** message

Challenges & Solutions

Challenge 1: Key Size Error

Problem: "ee key too small" - 1024-bit keys rejected
Solution: Used 2048-bit keys for better security

Challenge 2: Certificate Trust

Problem: Browser security warnings
Solution: Manual CA certificate import

Challenge 3: File Path Issues

Problem: Incorrect file paths in Apache configuration
Solution: Used absolute paths and verified file locations

Real-world Applications

Commercial Usage:

- **E-commerce sites** - Secure payment processing
- **Online banking** - Protected financial transactions
- **Web applications** - Secure user authentication
- **API endpoints** - Encrypted data transmission

Industry Standards:

- **Let's Encrypt** - Free automated certificates
- **Commercial CAs** - Verisign, Comodo, DigiCert

- **Browser Requirements** - HTTPS as default standard

Conclusion

Successfully implemented a complete SSL/TLS security infrastructure:

1. **Established own Certificate Authority**
2. **Issued and signed digital certificates**
3. **Configured Apache for HTTPS**
4. **Resolved browser trust issues**
5. **Deployed multiple secure websites**

The lab demonstrated the fundamental principles of web security, certificate-based authentication, and encrypted communication that form the backbone of secure internet communications.

Checkpoints Completion Status

- ✅ **Checkpoint-1:** CA Certificate & Basic HTTPS - 5 marks
- ✅ **Checkpoint-2:** webserverlab.com HTTPS - 5 marks
- ✅ **Checkpoint-3:** Apache HTTPS Deployment - 5 marks
- ✅ **Checkpoint-4:** Multiple HTTPS Sites - 5 marks

Total Marks: 20/20

Task-2 again with problems: Creating Certificate for example.com

What We Did:

1. Generated server key pair
2. Created Certificate Signing Request (CSR)
3. Signed certificate with our CA
4. Tested with OpenSSL server

Problems Faced & Solutions:

Problem 3: Key Size Too Small

Error: `ee key too small`
Solution: Used 2048-bit keys instead of 1024-bit

bash

```
openssl genrsa -des3 -out server.key 2048
```

Problem 4: Password Issues with Encrypted Keys

Error: `bad decrypt` - Wrong passwords
Solution: Created password-less keys for lab testing

bash

```
openssl req -new -x509 -keyout ca.key -out ca.crt -nodes
```

Problem 5: Browser Security Warnings

Error: Firefox/Chrome security warnings
Solution: Manually imported CA certificate to browser trust store

---

Task-3: Deploying HTTPS in Apache

What We Did:

1. Enabled Apache SSL module
2. Configured virtual hosts for HTTPS
3. Restarted Apache with SSL configuration

Problems Faced & Solutions:

Problem 6: Apache Configuration Errors

Error: `SSLCertificateFile: file does not exist`
Solution: Corrected file paths in Apache configuration

apache

```
SSLCertificateFile /var/www/anothervhost.com/html/lab5_ssl/server.crt

SSLCertificateKeyFile /var/www/anothervhost.com/html/lab5_ssl/server.key
```

Problem 7: SSL Passphrase Timeout

Error: Apache restart timeout waiting for passphrase
Solution: Used password-less keys for lab environment

bash

```
openssl rsa -in server.key -out server.key.nopass
```

Problem 8: Subject Alternative Names (SAN) Missing

Error: `ERR_CERT_COMMON_NAME_INVALID` in Chrome
Solution: Added SAN to certificates

bash

```
openssl x509 -req -in server.csr -CA ca.crt -CAkey ca.key -out server.crt -days 365 -extfile
<(printf "subjectAltName=DNS:example.com")
```

Technical Concepts Learned

1. Public Key Infrastructure (PKI)

- **Certificate Authority (CA)** - Trusted entity that issues certificates
- **Digital Certificates** - Electronic documents proving identity
- **Certificate Signing Request (CSR)** - Request for certificate issuance

2. SSL/TLS Handshake Process

1. Client hello with supported ciphers
2. Server certificate presentation
3. Client verification of certificate
4. Session key exchange
5. Encrypted communication

3. Browser Security Model

- **Trust Stores** - Pre-installed trusted CAs
- **Certificate Validation** - Chain of trust verification
- **Security Warnings** - When certificates are invalid or self-signed

4. Apache SSL Module

- **mod_ssl** - Apache module for SSL/TLS support
- **Virtual Host Configuration** - Separate HTTP and HTTPS configurations
- **Certificate Files** - PEM format for keys and certificates

---

Step-by-Step Successful Implementation

Final Working Commands:

1. CA Creation:

bash

```
openssl req -new -x509 -keyout ca.key -out ca.crt -nodes -subj
"/C=BD/ST=Dhaka/O=SUST/CN=My Own CA"
```

2. Server Certificate:

bash

```
openssl genrsa -out server.key 2048

openssl req -new -key server.key -out server.csr -subj "/CN=example.com" -addext
"subjectAltName=DNS:example.com"

openssl x509 -req -in server.csr -CA ca.crt -CAkey ca.key -CAcreateserial -out server.crt
-days 365
```

3. Apache Configuration:

apache

```
<VirtualHost *:443>

    ServerName example.com

    DocumentRoot /var/www/example.com/html

    SSLEngine on

    SSLCertificateFile /path/to/server.crt

    SSLCertificateKeyFile /path/to/server.key

</VirtualHost>
```

4. Browser Trust Establishment:

- Import `ca.crt` to browser certificate store
- Trust for identifying websites

Checkpoints Completion Status

Checkpoint-1: ✅ CA Certificate & Basic HTTPS (5 marks)

- Successfully created CA and self-signed certificate
- Demonstrated OpenSSL HTTPS server
- Explained certificate chain of trust

Checkpoint-2: ✅ webserverlab.com HTTPS (5 marks)

- Created separate certificate for second domain
- Both domains working with HTTPS

Checkpoint-3: ✅ Apache HTTPS Deployment (5 marks)

- Enabled Apache SSL module
- Configured virtual hosts for HTTPS
- Successful HTTPS access to example.com

Checkpoint-4: ✅ Multiple HTTPS Sites (5 marks)

- Both example.com and webserverlab.com working with HTTPS
- Separate certificates for each domain

Key Learnings

Technical Skills:

1. **OpenSSL Certificate Management** - Creating CAs, generating keys, signing certificates
2. **Apache SSL Configuration** - Virtual host setup for HTTPS
3. **Browser Certificate Management** - Importing and trusting certificates
4. **Troubleshooting SSL Issues** - Common errors and solutions

Security Concepts:

1. **Public Key Cryptography** - Asymmetric encryption principles
2. **Certificate Chain of Trust** - How browsers verify website identity
3. **HTTPS Protocol** - HTTP over SSL/TLS encryption

4. **Browser Security Models** - How browsers handle untrusted certificates

Real-world Applications:

- E-commerce website security
- Online banking protection
- Secure API communications
- Web application security

Challenges Overcome

1. **Password Management** - Simplified for lab environment
2. **Browser Compatibility** - Different behaviors in Firefox vs Chrome
3. **Modern Security Requirements** - SAN requirements in certificates
4. **File Path Configuration** - Correct paths in Apache configuration
5. **Certificate Trust** - Establishing trust in browser environment