Lab 5 Report: Securing Apache Web Server

Task 1: Becoming a Certificate Authority

Objective

Create a root Certificate Authority (CA) and use it to issue digital certificates for web servers. Unlike commercial CAs like VeriSign, this lab creates a self-signed root CA certificate.

Setup

1. Configuration File Setup

The OpenSSL configuration file (`openssl.cnf`) was copied from `/usr/lib/ssl/openssl.cnf` and placed in the working directory. The following subdirectories were created as specified in the configuration:

- `demoCA/certs/` - Directory for issued certificates
- `demoCA/crl/` - Directory for Certificate Revocation Lists
- `demoCA/newcerts/` - Directory for new certificates
- `demoCA/index.txt` - Empty file for certificate database
- `demoCA/serial` - File containing serial number (e.g., "1000")

2. CA Certificate Generation

A self-signed certificate for the root CA was generated using the following command:

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

Output Files:

- `ca.key` - CA's private key (password protected)
- `ca.crt` - CA's public-key certificate (self-signed)

Information Provided:

- Country Name: BD (Bangladesh)
- State/Province: Sylhet
- Locality: Sylhet
- Organization: SUST_IICT
- Common Name: [CA Name]
- Password: [Set for CA key protection]

Creating Certificate for example.com

Step 1: Generate RSA Key Pair

```
openssl genrsa -out webserverlab.key 2048
```

This command generates a 2048-bit RSA key pair without password protection (for server use). The key is stored in `webserverlab.key`.

Step 2: Generate Certificate Signing Request (CSR)

```
openssl req -new -key webserverlab.key -out webserverlab.csr -config openssl.cnf
```

CSR Information:

- Country Name: BD
- State/Province: Sylhet

- Locality: Sylhet
- Organization: SUST_IICT
- Organizational Unit: section
- Common Name: webserverlab.com
- Email Address: admin@webserverlab.com
- Challenge Password: 1234
- Optional Company Name: webserverlab.com

Step 3: Sign Certificate with CA

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

Certificate Details:

- Serial Number: 1003 (0x1003)
- Validity: Nov 8 18:58:32 2025 GMT to Nov 8 18:58:32 2026 GMT (365 days)
- Subject: /C=BD/ST=Sylhet/L=Sylhet/O=SUST_IICT/OU=section/CN=webserverlab.com/emailAddress=admin@webserverlab.
- X509v3 Extensions:
  - Basic Constraints: CA:FALSE
  - Subject Key Identifier: 9A:23:D1:50:A2:8F:2F:5F:FA:5E:BA:BD:EC:23:50:B5:24:B0:5A:6F
  - Authority Key Identifier: D7:D8:C5:17:A8:50:9A:5B:53:96:B8:FE:6E:5F:91:4E:FC:08:01:F2

Task 2: Testing with OpenSSL Server

Objective

Test the generated certificates using OpenSSL's built-in SSL server before deploying to Apache.

Implementation

Step 1: Combine Key and Certificate

```
cp server.key server.pem
cat server.crt >> server.pem
```

This creates a single PEM file containing both the private key and certificate, which is required by OpenSSL's s_server command.

Step 2: Launch OpenSSL Server

```
openssl s_server -cert server.pem -www
```

The server listens on port 4433 by default.

Browser Configuration

Importing CA Certificate into Browser

Since the CA certificate is self-signed and not recognized by browsers, it must be manually imported:

Firefox:

1. Preferences → Advanced → View Certificates
2. Click "Import" and select `ca.crt`
3. Select "Trust this CA to identify web sites"
4. The CA certificate is now in Firefox's trusted certificate list

Chrome:

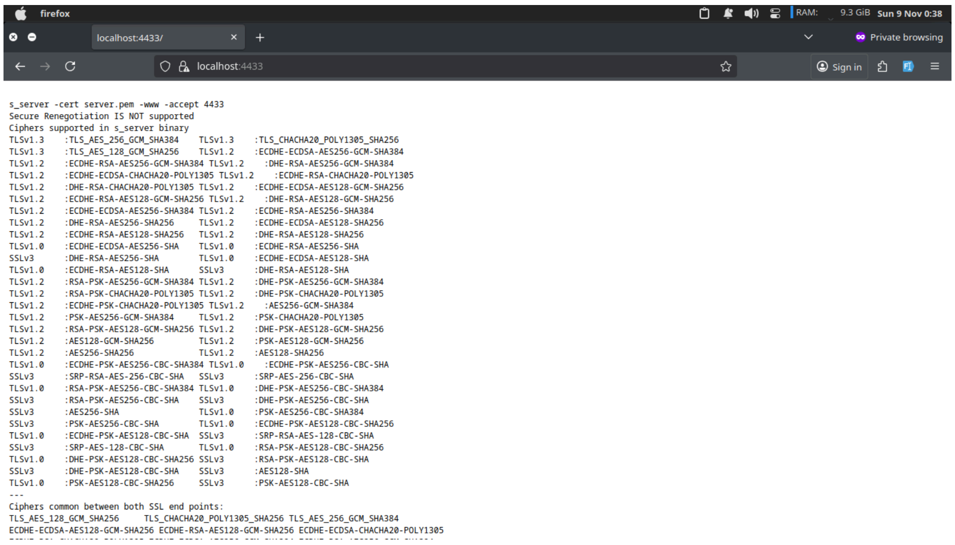
1. Settings → Privacy and Security → Security → Manage Certificates
2. Import `ca.crt` and trust it for identifying websites

Checkpoint 1: OpenSSL Server with example.com (5 Marks)

Accessing the Server:

1. **Via example.com:**
   - URL: `https://example.com:4433`
   - Since example.com points to 127.0.0.1, this resolves to localhost
2. **Via localhost:**
   - URL: `https://localhost:4433`
   - Direct access using localhost

Screenshot: HTTPS via localhost:4433



```
s_server -cert server.pem -www -accept 4433
Secure Renegotiation IS NOT supported
Ciphers supported in s_server binary
TLSv1.3    :TLS_AES_256_GCM_SHA384    TLSv1.3    :TLS_CHACHA20_POLY1305_SHA256
TLSv1.3    :TLS_AES_128_GCM_SHA256    TLSv1.2    :ECDHE-ECDSA-AES256-GCM-SHA384
TLSv1.2    :ECDHE-RSA-AES256-GCM-SHA384 TLSv1.2    :DHE-RSA-AES256-GCM-SHA384
TLSv1.2    :ECDHE-ECDSA-CHACHA20-POLY1305 TLSv1.2    :ECDHE-RSA-CHACHA20-POLY1305
TLSv1.2    :DHE-RSA-CHACHA20-POLY1305 TLSv1.2    :ECDHE-ECDSA-AES128-GCM-SHA256
TLSv1.2    :ECDHE-RSA-AES128-GCM-SHA256 TLSv1.2    :DHE-RSA-AES128-GCM-SHA256
TLSv1.2    :ECDHE-ECDSA-AES256-SHA384 TLSv1.2    :ECDHE-RSA-AES256-SHA384
TLSv1.2    :DHE-RSA-AES256-SHA256     TLSv1.2    :ECDHE-ECDSA-AES128-SHA256
TLSv1.2    :ECDHE-RSA-AES128-SHA256   TLSv1.2    :DHE-RSA-AES128-SHA256
TLSv1.0    :ECDHE-ECDSA-AES256-SHA    TLSv1.0    :ECDHE-RSA-AES256-SHA
SSLv3      :DHE-RSA-AES256-SHA        TLSv1.0    :ECDHE-ECDSA-AES128-SHA
TLSv1.0    :ECDHE-RSA-AES128-SHA      SSLv3      :DHE-RSA-AES128-SHA
TLSv1.2    :RSA-PSK-AES256-GCM-SHA384 TLSv1.2    :DHE-PSK-AES256-GCM-SHA384
TLSv1.2    :RSA-PSK-CHACHA20-POLY1305 TLSv1.2    :DHE-PSK-CHACHA20-POLY1305
TLSv1.2    :ECDHE-PSK-CHACHA20-POLY1305 TLSv1.2    :AES256-GCM-SHA384
TLSv1.2    :PSK-AES256-GCM-SHA384     TLSv1.2    :PSK-CHACHA20-POLY1305
TLSv1.2    :RSA-PSK-AES128-GCM-SHA256 TLSv1.2    :DHE-PSK-AES128-GCM-SHA256
TLSv1.2    :AES128-GCM-SHA256         TLSv1.2    :PSK-AES128-GCM-SHA256
TLSv1.2    :AES256-SHA256             TLSv1.2    :AES128-SHA256
TLSv1.0    :ECDHE-PSK-AES256-CBC-SHA384 TLSv1.0    :ECDHE-PSK-AES256-CBC-SHA
SSLv3      :SRP-RSA-AES-256-CBC-SHA   SSLv3      :SRP-AES-256-CBC-SHA
TLSv1.0    :RSA-PSK-AES256-CBC-SHA384 TLSv1.0    :DHE-PSK-AES256-CBC-SHA384
SSLv3      :RSA-PSK-AES256-CBC-SHA    SSLv3      :DHE-PSK-AES256-CBC-SHA
SSLv3      :AES256-SHA                TLSv1.0    :PSK-AES256-CBC-SHA384
SSLv3      :PSK-AES256-CBC-SHA        TLSv1.0    :ECDHE-PSK-AES128-CBC-SHA256
TLSv1.0    :ECDHE-PSK-AES128-CBC-SHA  SSLv3      :SRP-RSA-AES-128-CBC-SHA
SSLv3      :SRP-AES-128-CBC-SHA       TLSv1.0    :RSA-PSK-AES128-CBC-SHA256
TLSv1.0    :DHE-PSK-AES128-CBC-SHA256 SSLv3      :RSA-PSK-AES128-CBC-SHA
SSLv3      :DHE-PSK-AES128-CBC-SHA    SSLv3      :AES128-SHA
TLSv1.0    :PSK-AES128-CBC-SHA256     SSLv3      :PSK-AES128-CBC-SHA
---
Ciphers common between both SSL end points:
TLS_AES_128_GCM_SHA256     TLS_CHACHA20_POLY1305_SHA256 TLS_AES_256_GCM_SHA384
ECDHE-ECDSA-AES128-GCM-SHA256 ECDHE-RSA-AES128-GCM-SHA256 ECDHE-ECDSA-CHACHA20-POLY1305
```

Observations:

1. **Initial Warning:** Before importing the CA certificate, browsers display a security warning:
   - "example.com:4433 uses an invalid security certificate"
   - "The certificate is not trusted because the issuer certificate is unknown"
2. **After CA Import:** After importing `ca.crt` into the browser:
   - The browser recognizes the CA as trusted
   - The certificate chain is validated successfully
   - HTTPS connection is established with a secure padlock icon
   - The OpenSSL server displays the SSL connection information
3. **Certificate Chain:**
   - The server certificate (example.com) is signed by our CA
   - The browser validates the chain: example.com → Our CA (root)
   - Since our CA is trusted, the entire chain is valid
4. **HTTPS Protocol:**
   - The connection uses TLS/SSL encryption
   - All data between browser and server is encrypted

- The padlock icon indicates a secure connection

Explanation:

The HTTPS connection works as follows:

1. Browser sends a request to the server with supported cipher suites
2. Server responds with its certificate and selected cipher suite
3. Browser verifies the certificate chain (server cert → CA cert)
4. Browser generates a session key and encrypts it with the server's public key
5. Server decrypts the session key with its private key
6. Both parties use the session key for symmetric encryption of all subsequent data

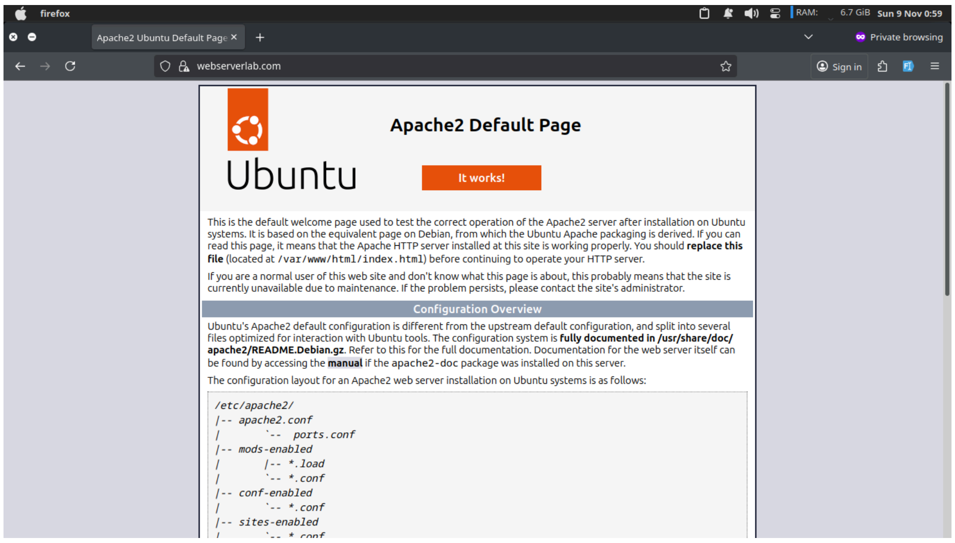
Checkpoint 2: OpenSSL Server with webserverlab.com (5 Marks)

Process:

The same procedure was followed for `webserverlab.com`:

1. Generated RSA key pair: `webserverlab.key`
2. Created CSR with Common Name: `webserverlab.com`
3. Signed certificate with CA: `webserverlab.crt`
4. Combined key and certificate into `webserverlab.pem`
5. Launched OpenSSL server with the certificate
6. Accessed via `https://webserverlab.com:4433`

Screenshot: HTTPS via webserverlab.com



Apache2 Default Page

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
```

Observations:

- Successfully accessed webserverlab.com via HTTPS on port 4433
- Certificate validation works correctly after CA import
- Secure connection established with proper encryption
- Server displays SSL connection details

Task 3: Deploy HTTPS into Apache

Objective

Deploy HTTPS capability into the Apache web server for the virtual hosts configured in Web Lab 1.

Implementation

Step 1: Enable SSL Module

```
sudo a2enmod ssl
```

This enables the SSL module in Apache, which is required for HTTPS functionality.

Step 2: Configure Virtual Host for HTTPS

The virtual host configuration file for `example.com` was updated to include HTTPS support:

```
<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 /etc/apache2/ssl/webserverlab.crt    SSLCertificateKeyFile /etc/apache2/ssl/webserverlab.key</VirtualHost></IfModule>
```

Step 3: Copy Certificates to Apache SSL Directory

```
sudo cp webserverlab.crt /etc/apache2/ssl/
sudo cp webserverlab.key /etc/apache2/ssl/
```

Step 4: Set Proper Permissions

```
sudo chmod 644 /etc/apache2/ssl/webserverlab.crt
sudo chmod 600 /etc/apache2/ssl/webserverlab.key
```

- Certificate file: Readable by Apache (644)
- Private key: Only readable by owner (600) for security

Step 5: Test Apache Configuration

```
sudo apache2ctl configtest
```

Output: `Syntax OK`

This confirms that the Apache configuration is correct and there are no syntax errors.

Step 6: Restart Apache

```
sudo systemctl restart apache2
```

Apache Status:

```
● apache2.service - The Apache HTTP Server
     Loaded: loaded (/usr/lib/systemd/system/apache2.service; disabled; preset: enabled)
     Active: active (running) since Sun 2025-11-09 00:59:23 +06
       Docs: https://httpd.apache.org/docs/2.4/
    Process: 71713 ExecStart=/usr/sbin/apachectl start (code=exited, status=0/SUCCESS)
   Main PID: 71773 (apache2)
      Tasks: 55 (limit: 16443)
     Memory: 6.7M (peak: 8.5M)
        CPU: 42ms
```

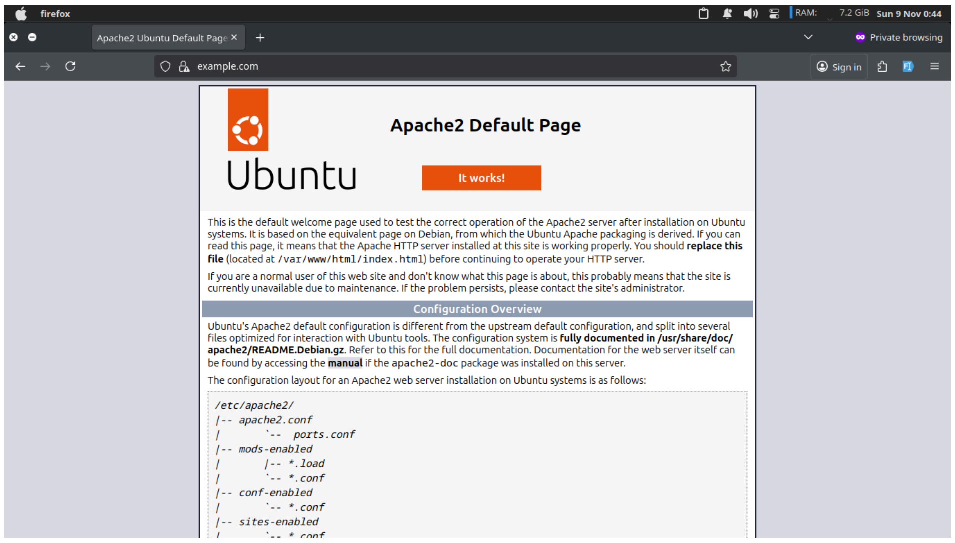
Apache is running successfully with SSL support enabled.

Checkpoint 3: HTTPS on Apache for example.com (5 Marks)

Accessing the Server:

- URL: `https://example.com`
- Port: 443 (default HTTPS port)

Screenshot: HTTPS via example.com



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```

Observations:

1. **Secure Connection:** The website loads successfully over HTTPS
2. **Certificate Validation:** The browser validates the certificate chain correctly
3. **Padlock Icon:** The secure padlock icon appears in the address bar
4. **No Warnings:** After importing the CA certificate, no security warnings are displayed
5. **Encrypted Communication:** All data between browser and server is encrypted using TLS/SSL

Configuration Verification:

- SSL module is enabled and loaded
- Virtual host is configured for port 443
- Certificate and key files are properly referenced
- Apache is listening on port 443
- HTTPS connection is established successfully

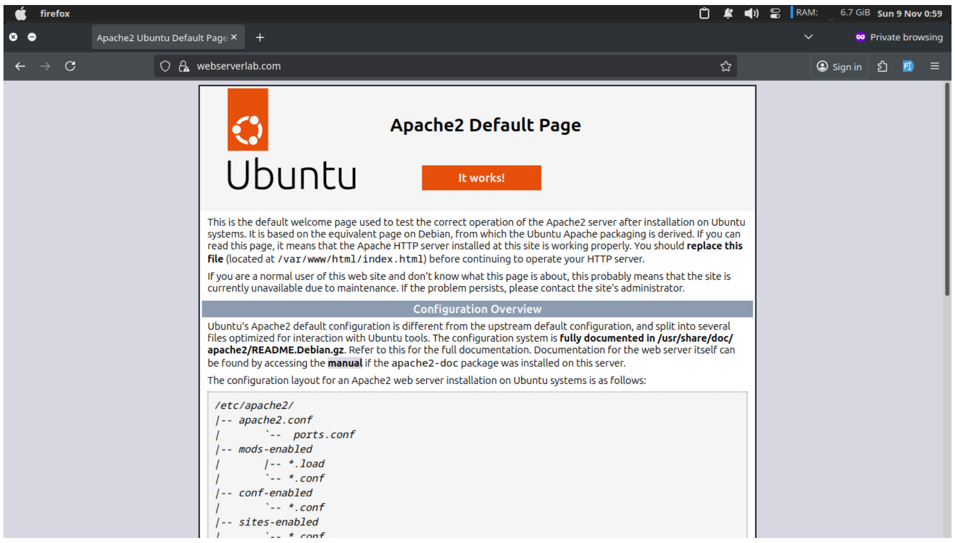
Checkpoint 4: HTTPS on Apache for webserverlab.com (5 Marks)

Process:

The same HTTPS configuration was applied to `webserverlab.com`:

1. Created certificate for webserverlab.com (as shown in Task 1)
2. Configured virtual host for HTTPS on port 443
3. Copied certificate and key to `/etc/apache2/ssl/`
4. Set proper file permissions
5. Tested configuration and restarted Apache
6. Accessed via `https://webserverlab.com`

Screenshot: HTTPS via webserverlab.com



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|       `-- *.conf
|-- sites-enabled
|       `-- *.conf
```

Observations:

- Successfully configured HTTPS for webserverlab.com
- Certificate is properly signed by our CA
- Secure connection established on port 443
- Website loads correctly with encryption
- No security warnings after CA certificate import