Programming OpenSSL

The Server Perspective

by

Sean Walton

Host Addressing & Ports

- Hosts use addresses to interconnect.
- TCP/IP uses a 4-byte number for Ids.

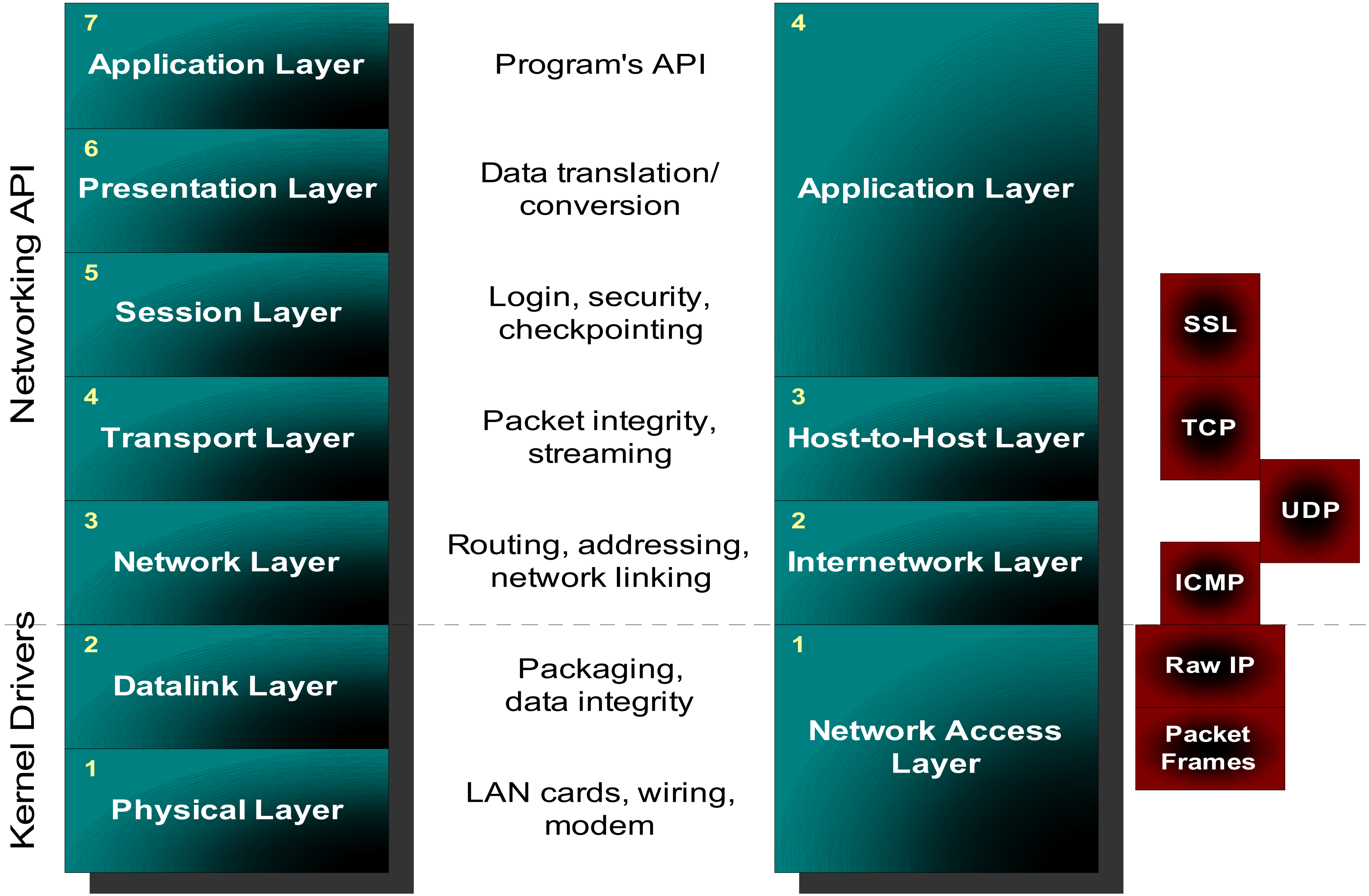
  `128.98.2.254`

- TCP adds ports to addresses for services.
  - Ports can be between 1-65535
  - System services are between 1-1023
  - User services are between 1024-65535

    `198.176.2.45:80` or `12.63.99.240.3246`

OSI Model

DoD Model



Networking API

7 Application Layer — Program's API

6 Presentation Layer — Data translation/ conversion

5 Session Layer — Login, security, checkpointing

4 Transport Layer — Packet integrity, streaming

3 Network Layer — Routing, addressing, network linking

Kernel Drivers

2 Datalink Layer — Packaging, data integrity

1 Physical Layer — LAN cards, wiring, modem

4 Application Layer

3 Host-to-Host Layer

2 Internetwork Layer

1 Network Access Layer

SSL

TCP

UDP

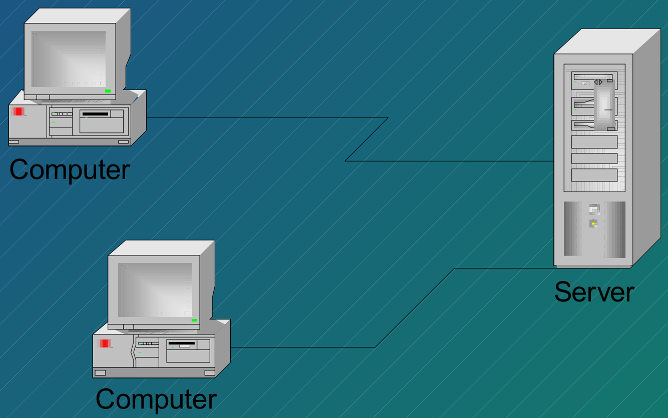
ICMP

Raw IP

Packet Frames

Basic Client/Server

- Networked hosts connect through sockets.
- Servers publish services through ports.
- Clients connect to the ports.



Client Algorithm

The Basic Client:

- Sets up socket.
- Connects to server.
- Sends command.
- Retrieves reply.
- Closes socket.

```
int sd;
struct sockaddr_in addr;
sd= socket(PF_INET,SOCK_STREAM,0);
bzero(&addr, sizeof(addr));
addr.sin_family= AF_INET;
addr.sin_port= htons(80);
aton(“127.0.0.1”, &addr.sin_addr);
connect(sd, &addr, sizeof(addr));
send(sd, msg, msglen, 0);
recv(sd, reply, replylen, 0);
close(sd);
```

Server Algorithm

The Basic Server:

- Sets up socket.
- Publishes port.
- Socket→listener.
- Awaits connection.
- Gets command.
- Sends reply.
- Closes connection.

```
int sd, client;
struct sockaddr_in addr;
sd= socket(PF_INET,SOCK_STREAM,0);
bzero(&addr, sizeof(addr));
addr.sin_family= AF_INET;
addr.sin_port= htons(80);
aton(“127.0.0.1”, &addr.sin_addr);
bind(sd, &addr, sizeof(addr));
listen(sd, 10);
client= accept(sd, 0, 0);
recv(client, cmd, cmdlen, 0);
send(client, reply, replylen, 0);
close(client);
```

Secure Sockets

- Building on top of TCP/IP.
- Using keys and ciphers.
- Offering certificates.
- Verifying message with a Message Digest.
- Extending the handshake.

OpenSSL Sits on Top of TCP/IP

- Simplifies interface with TCP/IP stack.
- Simplifies programming.
- Limits session recoverability.
- Keeps interface clean and direct.

Keys and Ciphers

- Ciphers are encryption algorithms.
- Keys are numbers within a special range.
- Private-key ciphers
  - Use the same key to encrypt & decrypt data
  - Have highest security
  - Are very fast.
- Public-key ciphers
  - Require two keys: encryption & decryption
  - Are <25% as secure as private keys
  - Are very slow.

Certificates

- Solves the “Man in the Middle” dilemma.
- Solve the problem of host identification with a trusted third party.
- Contain information about the server:
  - Who owns the certificate
  - Who issued the certificate
  - Where the owner is located
  - When the certificate will expire.

Message Digest

- “Summarizes” the message.
- Must be irreversible (real data cannot be recovered from digest value).
- Most message digests are hash functions.
- Combined with an encryption key yields the Message Authentication Code (MAC).

Different Handshakes

- TCP offers the “Three-Way Handshake”.
  - Client extends request (SYN)
  - Server accepts (ACK) and reciprocates (SYN)
  - Client accepts and begins communications

Extending the Handshake

- Client sends cipher list & random number.
- Server indicates cipher, sends certificate, public key & random number.
- Client verifies certificate and sends an encrypted private key with public key.
- Server accepts private key and sends own private key.

OpenSSL Initialization

- Build algorithm tables.
- Load error messages.
- Select interface methods.
- Create new context.

```
SSL_METHOD *method;
SSL_CTX *ctx;
OpenSSL_add_all_algorithms();
SSL_load_error_strings();
method= SSLv2_server_method();
ctx= SSL_CZTX_new(method);
```

Initialization (cont.)

- Load certificates file.
- Load private keys file.
- Verify private keys.

```
SSL_CTX_use_certificate_file(ctx, CertFile,
   SSL_FILETYPE_PEM);
SSL_CTX_use_PrivateKey_file(ctx, KeyFile,
   SSL_FILETYPE_PEM);
if ( !SSL_CTX_check_private_key(ctx) )
   fprintf(stderr, “Files don’t match!”);
```

Set Up Server Socket

. . .

Use the same algorithm for setting up server!

Attach Client to SSL

- Create SSL instance.
- Attach client to instance.
- Establish SSL handshake.
- Commence transactions.

```
SSL *ssl;
ssl= SSL_new(ctx);
SSL_set_fd(ssl, client);
SSL_accept(ssl);
SSL_read(ssl, cmd, cmdlen);
SSL_write(ssl, reply, replylen);
```

OpenSSL Features

- Offers direct development path from sockets.
- Simplifies interfacing.
- Can create private certificates.
- Supports multi-threading.
- Interfaces directly with off-the-shelf browsers.
- Supports multiple platforms & OSs.
- Is GPL!

Q & A

www.cs.utah.edu/~swalton