Angels (Open SSL) and D(a)emons

15-441: Computer Networks

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Extras

ssl_example.c
ssl_client.py
daemonize.c
(on course website)
PJ1 Final Submission

(1) SSL
(2) CGI
(3) Daemonize
SSL
Getting a... Domain Name
Create a Domain Name

• Get a **free** domain name from **No-IP**

[Image of No-IP Free]

No-IP Free is our entry level service. Use yourname.no-ip.org instead of a hard to remember IP address or URL. With No-IP Dynamic DNS, our free Dynamic Update Client keeps track of your changing IP address and updates your hostname, keeping your connection active.

[Sign Up Now] [More]

• Use your **Andrew ID** as the **hostname**

[Hostname: dnaylor] [no-ip.biz]
Get the Update Client

- You don't have root, so...
  - Just build (make), don't install (make install)
  - Run manually when your IP changes
Create No-IP Conf File

./noip2 -C -c noip.conf

[dnaylor@unix3 ~]$ ./noip2 -C -c noip.conf

Auto configuration for Linux client of no-ip.com.
Please enter the login/email string for no-ip.com  <username>
Please enter the password for user '<username>'  ***************
Only one host [dnaylor.no-ip.biz] is registered to this account.
It will be used.

Please enter an update interval:[30]

Do you wish to run something at successful update?[N] (y/N)

New configuration file 'noip.conf' created.
Update Your IP Address

./noip2 -c noip.conf -i 108.17.82.243

[dnaylor@unix3 ~/noip-2.1.9-1]$ ./noip2 -c noip.conf -i 108.17.82.243
IP address detected on command line.
Running in single use mode.
Getting a... Certificate
15-441 Certificate Authority

http://gs11697.sp.cs.cmu.edu/keyserver
You Need 3 Things

1) CA certificate
2) Your private key
3) Your certificate
Add CA Cert to Your System/Browser
e.g., add to OSX Keychain
Implementing an SSL Server
What is SSL?

- Standard behind secure communication on the Internet.
- Provides confidentiality & integrity
- Sits between transport & application
OpenSSL Toolkit

- Command line tools, SSL library, and crypto library
- Can do a lot more than SSL
  - Message digests
  - Encryption and decryption of files
  - Digital certificates
  - Digital signatures
  - Random number generation
SSL Server In a Nutshell

- Use the OpenSSL library, here is a link to their documentation.
- Create a second server socket in addition to the first one, use the passed in SSL port from the command line arguments.
- Add this socket to the select() loop just like your normal HTTP server socket.
- Whenever you accept connections, wrap them with the SSL wrapping functions.
- Use the special read() and write() SSL functions to read and write to these special connected clients.
- In the select() loop, you need to know if a socket you are dealing with is SSL wrapped or not.
- Use appropriate IO depending on the 'type' of socket---although use select() for all fd's.
- Use your private key and certificate file that you obtained earlier.
Open SSL headers

/* OpenSSL headers */
#include <openssl/bio.h>
#include <openssl/ssl.h>
#include <openssl/err.h>
Initialization Steps

- Global System Initialize
  - SSL_library_init()
  - SSL_load_error_strings()
- Initialize SSL_METHOD and SSL_CTX
  - meth=SSLv23_method();
  - ctx=SSL_CTX_new(meth);
- Loading keys
  - SSL_CTX_use_certificate_file(…)
  - SSL_CTX_use_PrivateKey_file(…)
Global Initialization

- SSL_library_init()
  - registers the available SSL/TLS ciphers and digests.

- SSL_load_error_strings()
  - Provide readable error messages.
SSL_METHOD

- To describe protocol versions
- SSLv1, SSLv2 and TLSv1

```c
SSL_METHOD* meth = TLSv1_method();
```
SSL_CTX

- Data structure to store keying material
- Reused for all connections; make ONE for your server

```c
SSL_CTX* ctx = SSL_CTX_new(meth);
```
SSL_CTX_use_certificate_file()

- Loads the first certificate stored in file into ctx.
- The formatting type of the certificate must be specified from the known types
  - SSL_FILETYPE_PEM
  - SSL_FILETYPE_ASN1.
- Our CA generates files of PEM format

```c
int SSL_CTX_use_certificate_file(SSL_CTX *ctx, const char *file, int type);
```
SSL_CTX_use_PrivateKey_file()

- Adds the first private key found in file to ctx.
- The formatting type of the certificate must be specified from the known types:
  - SSL_FILETYPE_PEM
  - SSL_FILETYPE_ASN1.
- Our CA generates files of PEM format

```c
int SSL_CTX_use_PrivateKey_file(SSL_CTX *ctx, const char *file, int type);
```
Wrapping Connections

- Create new SSL structure using `SSL_new()`
- Connect it to the socket using `SSL_set_fd()`
- Perform handshake using `SSL_accept()`
- Read and write using `SSL_read()` and `SSL_write()`
- Perform shutdown at the end, also need to clear state and close underlying I/O socket etc.
- As always, check for return value and handle errors appropriately!
SSL_new()

- Creates a new SSL structure
- Create one per connection
- Inherits the settings of the underlying context.

```c
SSL* ssl = SSL_new(ctx);
```
SSL_set_fd()

- Tell the SSL object which socket it will wrap

```c
int SSL_set_fd(SSL *ssl, int fd);
```
SSL_accept

- SSL_accept - wait for a TLS/SSL client to initiate a TLS/SSL handshake

```c
int SSL_accept(SSL *ssl)
```

- (Do this after a standard `accept()`.)
SSL_read and SSL_write

- SSL_read to read bytes from a TLS/SSL connection
  ```c
  int SSL_read(SSL *ssl, void *buf, int num);
  ```
- SSL_write to write bytes to a TLS/SSL connection
  ```c
  int SSL_write(SSL *ssl, const void *buf, int num);
  ```
- NOTE:
  - The data are received in records (with a maximum record size of 16kB for SSLv3/TLSv1).
  - Only when a record has been completely received, it can be processed (decryption and integrity check)
SSL_shutdown

- Shuts down an active TLS/SSL connection.

```c
int SSL_shutdown(SSL *ssl);
```

- (Then do a standard `close`().)
BIO - Optional

- I/O abstraction provided by OpenSSL
- Hides the underlying I/O and can set up connection with any I/O (socket, buffer, ssl etc)
- BIOs can be stacked on top of each other using push and pop!
- NOTE: You don't have to necessarily use BIO for this project! The next few slides describe creating BIO and working with it.
BIO_new()

- Returns a new BIO using method type.
- Check BIO_s_socket(), BIO_f_buffer(), BIO_f_ssl()
- Check BIO_new_socket()

```c
BIO * BIO_new(BIO_s_socket());
BIO_set_fd(sbio, sock, BIO_NOCLOSE);
```
SSL_set_bio()

- Connects the BIOs rbio and wbio for the read and write operations of the TLS/SSL (encrypted) side of ssl

```c
void SSL_set_bio(SSL *ssl, BIO *rbio, BIO *wbio)
```
Example of Stacking BIOs

```c
buf_io = BIO_new(BIO_f_buffer());
/* create a buffer BIO */
ssl_bio = BIO_new(BIO_f_ssl());
/* create an ssl BIO */
BIO_set_ssl(ssl_bio, ssl, BIO_CLOSE);
/* assign the ssl BIO to SSL */
BIO_push(buf_io, ssl_bio);
```
BIO_read() and BIO_write()

- Attempts to read len bytes from BIO b and places the data in buf.
  
  ```c
  int BIO_read(BIO *b, void *buf, int len);
  ```

- Attempts to write len bytes from buf to BIO b.

  ```c
  int BIO_write(BIO *b, const void *buf, int len);
  ```
SSL

Questions?
Daemonizing
Orphaning

- Fork the process to create a copy (child)
- Let parent exit!
- The child will become child of init process
  - Start operating in the background

```c
int pid = fork();
if (pid < 0) exit(EXIT_FAILURE); /* fork error */
if (pid > 0) exit(EXIT_SUCCESS); /* parent exits */
/* child (daemon) continues */
```
Process Independence

- Process inherits parent's controlling tty; need to detach
- Server should not receive signals from the process that started it
- Operate independently from other processes

setsid() /*obtain a new process group*/
Close File Descriptors

• Close all open descriptors inherited
  ```c
  int i;
  for (i = getdtablesize(); i >= 0; --i)
      close(i);
  ```

• Connect standard I/O descriptors (stdin 0, stdout 1, stderr 2) to /dev/null
  ```c
  i = open("/dev/null", O_RDWR); /* open stdin */
  dup(i) /* stdout */
  dup(i) /* stderr */
  ```
File Creation Mask

- Servers run as super-user
- Need to protect the files they create
- File creation mode is 750 (complement of 027)

umask(027);
Running Directory

- Server should run in a known directory

  chdir("/servers/");
Mutual Exclusion

- We want only one copy of the server (file locking)
- Record pid of the running instance!
  - `cat lisod.lock` more efficient than `ps -ef | grep lisod`

```c
lfp = open(lock_file, O_RDWR|O_CREAT, 0640);
if (lfp < 0)
    exit(EXIT_FAILURE); /* cannot open */
if (lockf(lfp, F_TLOCK, 0) < 0)
    exit(EXIT_SUCCESS); /* cannot lock */
sprintf(str, "%d\n", getpid());
write(lfp, str, strlen(str)); /*record pid to lockfile */
```
Logging

- You sent stdout and stderr to /dev/null, so you need to log to a file!
Daemonizing Questions?