TALES FROM THE CRYPTO
INTRODUCTION

Kirk Jackson
Xero
http://www.xero.com
http://www.codecamp.co.nz
http://www.ignitewellington.co.nz
http://pageofwords.com

Graeme Neilson
Aura Software Security
Security Researcher
http://www.aurasoftwaresecurity.co.nz
Cryptography

What is it good for...?
- Confidentiality  ...sssh it might hear you!
- Authentication  who's there...?
- Integrity      ...I have not been possessed!
- Non-repudiation who said that...?

When do I use...?
- Hashing
- Symmetric encryption
- Asymmetric cryptography

Beware of implementations not algorithms

Kerckhoff's Principle
The security of a system should reside only in the key

Disco Principle
Don't invent Super Crypto of Your Own
Hashing

Plain Text \rightarrow \text{Hash function} \rightarrow \text{Hash (fixed size)}

\text{Can’t reverse}
One way functions for:
- Integrity checks
- Password storage

Using hash algorithms
- Use SHA family not MD5
- NIST hash competition

TALES FROM THE CRYPTO
- Juniper Netscreen password hash algorithm
JUNIPER NETSCREEN
PASSWORD HASH

FIPS140-2 Security Policy for Netscreen 5400 and Netscreen-ISG 2000 states

"The following non-approved algorithms/protocols are disabled in FIPS mode: RSA encryption/decryption, DES, MD5, SNMPv3"

Algorithm:
- MD5 hash of username + “:Administration Tools:” + password
- Base64 encode the hash
- Insert the characters 'n' 'r' 'c' 's' 't' 'n' at fixed positions (netscreen backwards excluding the letter 'e')

Weaknesses
- It's MD5!
- Salt is the username and a constant string so susceptible to Rainbow Table attack
The password problem

- Storing plain-text password in the DB
- Beware the ‘forgot password’ email with the password sent in plain-text

```csharp
public void ChangePassword(User user, string newPassword)
{
    user.Password = newPassword;
    user.Save();
}
```

```csharp
public bool CheckPassword(User user, string password)
{
    return user.Password == password;
}
```
Store and Compare a Hash

- Storing a hash of the password in the DB
- Now we have to compare hashes, rather than plain-text

```csharp
public void ChangePassword(User user, string newPassword)
{
    string hash = HashPassword(newPassword);
    user.PasswordHash = hash;
    user.Save();
}
```

```csharp
public bool CheckPassword(User user, string password)
{
    string hash = HashPassword(password);
    return user.PasswordHash == hash;
}
```
Computing a hash

- Most libraries have decent hash functions
- A given input always gives the same output

```csharp
public string HashPassword(string input)
{
    UTF8Encoding encoder = new UTF8Encoding();
    SHA256Managed algorithm = new SHA256Managed();
    byte[] hashedDataBytes = algorithm.ComputeHash(encoder.GetBytes(input));
    return byteArrayToString(hashedDataBytes);
}
```
Lookup Tables

Lookup a potential password given a hash

Rainbow table:
A faster algorithm for looking up
Use the salt

- Store a different random salt for each user
- Append the salt when hashing the password

```csharp
public void ChangePassword(User user, string newPassword)
{
    user.Salt = GenerateRandomSalt();
    string hash = HashPassword(user.Salt, newPassword);
    user.PasswordHash = hash;
    user.Save();
}
```

```csharp
public bool CheckPassword(User user, string password)
{
    string hash = HashPassword(user.Salt, password);
    return user.PasswordHash == hash;
}
```
**Generate a Salt**

```csharp
public byte[] GenerateRandomSalt()
{
    byte[] saltBytes = new byte[saltSize];
    RNGCryptoServiceProvider rng = new RNGCryptoServiceProvider();
    rng.GetBytes(saltBytes);
    return saltBytes;
}
```

- Use a cryptographically secure pseudorandom number generator
  - System.Random isn’t

```csharp
public string HashPassword(byte[] salt, string input)
{
    UTF8Encoding encoder = new UTF8Encoding();
    SHA256Managed algorithm = new SHA256Managed();
    byte[] saltedInput = JoinArrays(salt, encoder.GetBytes(input));
    byte[] hashedDataBytes = algorithm.ComputeHash(saltedInput);
    return byteArrayToString(hashedDataBytes);
}
```
**Symmetric Encryption**

Plain Text

Cipher Text

Encrypt (key)

Decrypt (key)
SYMMETRIC ENCRYPTION

Many encryption algorithms

Rijndael won the NIST competition to replace DES
Rijndael == AES
AES Finalists: Rijndael, Serpent, Twofish, RC6, MARS
Not recommended: DES, 3DES, IDEA, RC4

Birthday Attack:
  • System of N elements
  • Collision after square root of N
  • Need 23 people to have a collision of birthdays
  • 256 bit key provides 128 bit encryption strength

TALES FROM THE CRYPTO
FORTIGATE HARD DISK ENCRYPTION
FORTIGATE DISK ENCRYPTION

Uses AES_ECB

Watermarking is visible on the disk – blocks of identical ciphertext

The same plain text encrypts to the same ciphertext

Disk contains known plain text

We can subvert the system to carry out chosen plaintext attacks
Write attacker specified plaintext to the disk

Symmetric key is on the system
Forms Auth Cookies

```csharp
FormsAuthenticationTicket authTicket = new
    FormsAuthenticationTicket(1, // version
        txtUserName.Text, // user name
        DateTime.Now, // creation
        DateTime.Now.AddMinutes(60), // Expiration
        false, // Persistent
        roles // User Data
    );

string encryptedTicket = FormsAuthentication.Encrypt(authTicket);

HttpCookie authCookie = new HttpCookie(FormsAuthentication.FormsCookieName,
    encryptedTicket);
```

---

Hash, Encrypt

Decrypt, Validate

Keep the machine keys secure
Asymmetric Encryption

Encrypt (public key)

Plain Text -> Cipher Text

Decrypt (private key)

Cipher Text -> Plain Text
ASYMMETRIC ENCRYPTION

Here comes a massive over simplification:
Exploits mathematical operations that are easy but whose inverse operations are hard™

For example:
Multiplying two primes is easy.
Finding the prime factors of a BIG integer is hard.

Certificate Revocation / PKI

- Brute force key search so choose an appropriate key size
- Side channel attacks
- Man in the middle
- Source of randomness must be random – really random

TALES FROM THE CRYPTO
- Debian versus OpenSSL
All keys generated on Linux Debian based systems SEP 2006 – MAY 2008 affected

To fix a Vlgrind warning regarding uninitialised variables a maintainer of Debian patched OpenSSL and broke the random number generator.

Only seed for the random number generator became the process ID: 1 - 32768

For each algorithm and key size only 32767 possible key values.

In practice:

- Keys generated at boot time will have a PID less than 500
- User generated keys PID between 500 and 10,000
- Most keys will have a PID between 1 and 3000
Asymmetric Example

```csharp
X509Store certStore = new X509Store("My", StoreLocation.LocalMachine);
certStore.Open(OpenFlags.ReadOnly | OpenFlags.OpenExistingOnly);

X509Certificate2Collection certificateCollection =
certStore.Certificates.Find(X509FindTypeFindBySubjectName, _certificateSubject);

HttpWebRequest webRequest = HttpWebRequest.Create("http://foo.com");
webRequest.ClientCertificates.Add(certificate);
```
Secure Sockets Layer

Hashing for Message Authentication

Symmetric encryption for confidentiality

Asymmetric encryption for
  • authentication
  • symmetric encryption key exchange.

Cypher suite: protocol, authentication, encryption, message authentication code

e.g. TLS_RSA_WITH_AES_128_CBC_SHA256
Certificates

• Use strong certificates (key size of 2048 bit from 2010)
• Protect the private keys
• Get certificates for all used domain names
  • Conditioning users to certificate errors is not acceptable
  • Wildcard (*.example.com) or enhanced wildcard (a.example.com, b.example.com) are options
Use Strong SSL Versions

History:


Best practice: use TLS v1.0 and above

IE7, Firefox 2.0 and newer (IE6 via patch)

Never use SSL v2. Use SSL v3 under duress.
**Only Support Strong Cryptographic Cyphers**

- Use AES for encryption
- Use CBC mode
- Use SHA for digest
- MD5 may be used within the TLS protocol
- Do not provide support for NULL ciphersuites

[SSL Cipher Check, How to disable](#)
SSL / TLS Cheat Sheet

- Use TLS for All Login Pages and All Authenticated Pages
- Use TLS on Any Networks (External and Internal) Transmitting Sensitive Data
- Do Not Provide Non-TLS Pages for Secure Content
- Do Not Mix TLS and Non-TLS Content
- Use "Secure" Cookie Flag
- Keep Sensitive Data Out of the URL
- Do Not Perform Redirects from Non-TLS Page to TLS Login Page

DISABLING SSLV2

Apache
SSLProtocol -ALL +SSLv3 +TLSv1
SSLCipherSuite ALL:!aNULL:!ADH:!eNULL:!LOW:!EXP:RC4+RSA:+HIGH:+MEDIUM

IIS
[HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Control\SecurityProviders\SCHANNEL\Protocols\PCT 1.0\Server]
"Enabled"=dword:00000000
[HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Control\SecurityProviders\SCHANNEL\Protocols\SSL 2.0\Server]
"Enabled"=dword:00000000

[HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Control\SecurityProviders\SCHANNEL\Ciphers\DES 56/56]
"Enabled"=dword:00000000
[HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Control\SecurityProviders\SCHANNEL\Ciphers\NULL]
"Enabled"=dword:00000000
[HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Control\SecurityProviders\SCHANNEL\Ciphers\RC2 40/128]
"Enabled"=dword:00000000
[HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Control\SecurityProviders\SCHANNEL\Ciphers\RC2 56/128]
"Enabled"=dword:00000000
[HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Control\SecurityProviders\SCHANNEL\Ciphers\RC4 40/128]
"Enabled"=dword:00000000
[HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Control\SecurityProviders\SCHANNEL\Ciphers\RC4 56/128]
"Enabled"=dword:00000000
[HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Control\SecurityProviders\SCHANNEL\Ciphers\RC4 64/128]
"Enabled"=dword:00000000
CRYPTOKEEPER SAYS

- Use cryptography
- Remember the Hoff’s
  - Hash with SHA
  - Encrypt with AES
- Protect your keys
- Randomness is vital