CIS 6930:
IoT Security

Lecture 6

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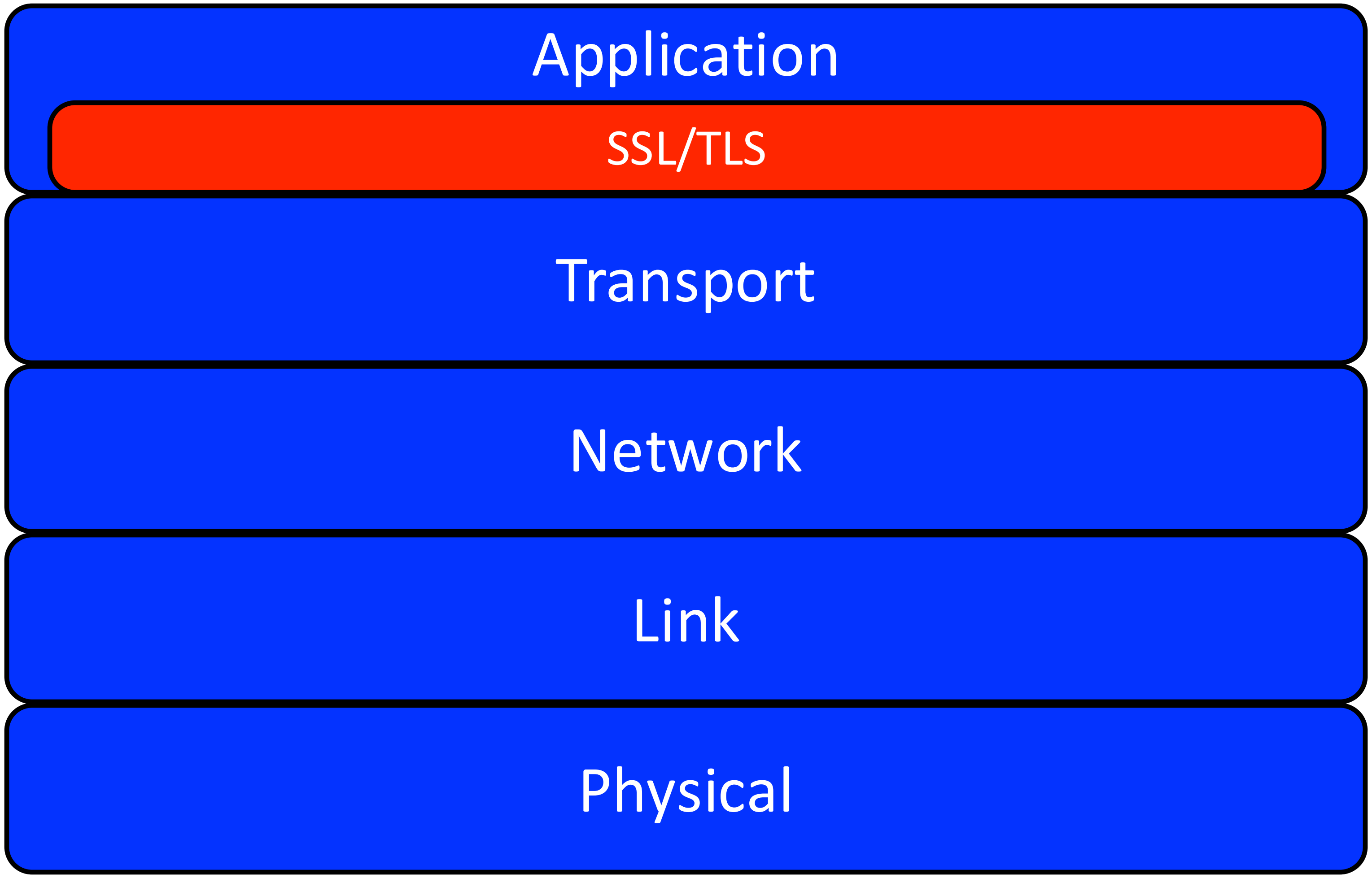
Class Notes and Clarifications

- Related Work
  - Learn relevant literature and where your research work fits
    - Seminal work in your topic
    - Recent work in your topic
  - Compare and contrast
- Finding sources:
  - Top conference websites/proceedings (ACM, IEEE, USENIX, NDSS…)
  - Semantic scholar/Google scholar/USF library

SSL/TLS in the Real World

Network Stack, revisited



The verifier matters

- SSL is an *application layer protocol*
  - Software developers must use it correctly

- Pre-Smartphone World
  - Small set of applications that use SSL (E.g., Web Browser)
  - Lots of attention to those apps

$\rightarrow$

- Smartphone World
  - Possibly *millions of applications that use SSL*
  - Many apps do not verify certificates correctly – **Implications?**
  - Developers change default configuration – **WHY?**

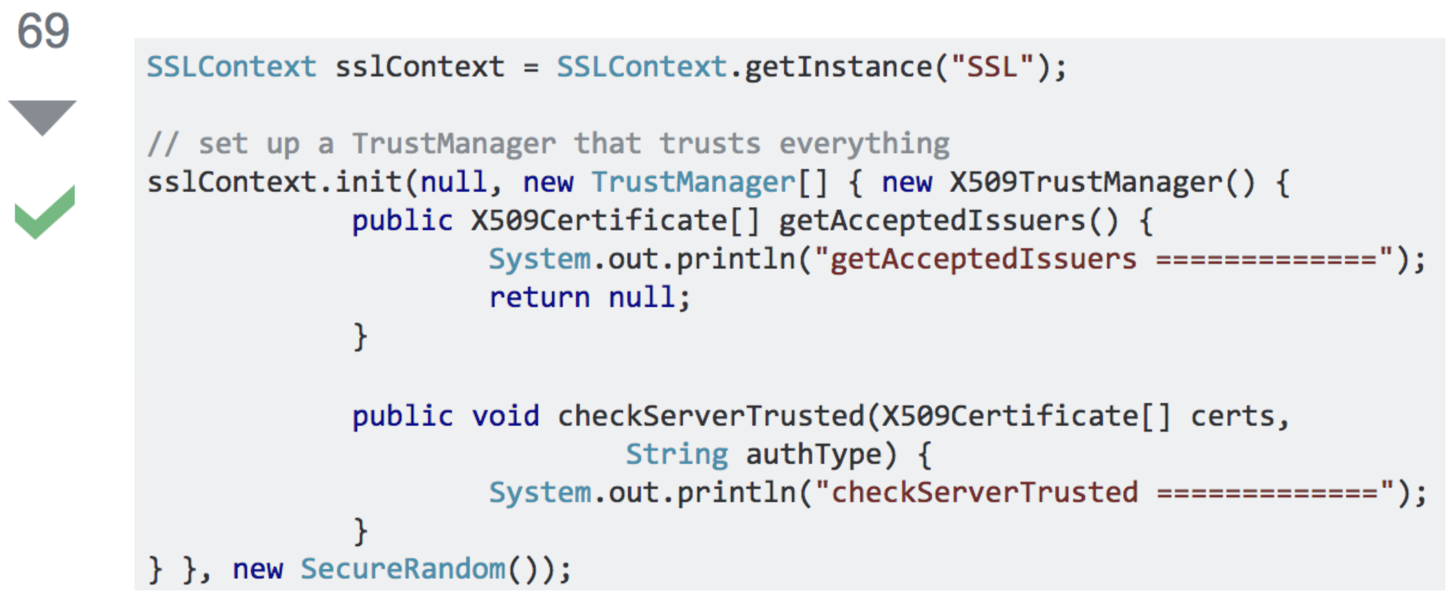
Mixed SSL use

- Mixed use of HTTP and HTTPS on the same site.
- **Use case 1:** <u>Login page is not HTTPS</u>, but the login form is submitted to a HTTPS page.
  - MiTM can *replace HTTPS links with HTTP* (i.e., SSL Stripping)
- **Use case 2:** Login page is HTTPS, but the <u>rest of the website may be HTTP</u>
  - *Unencrypted cookies/session IDs!* (e.g., Firesheep)

Lesson 2: Use HTTPS throughout

Certificate Validation

- Apps can override the *TrustManager* interface



```
SSLContext sslContext = SSLContext.getInstance("SSL");

// set up a TrustManager that trusts everything
sslContext.init(null, new TrustManager[] { new X509TrustManager() {
            public X509Certificate[] getAcceptedIssuers() {
                    System.out.println("getAcceptedIssuers =============");
                    return null;
            }

            public void checkServerTrusted(X509Certificate[] certs,
                            String authType) {
                    System.out.println("checkServerTrusted =============");
            }
} }, new SecureRandom());
```

https://stackoverflow.com/questions/2703161/how-to-ignore-ssl-certificate-errors-in-apache-httpclient-4-0

- What is wrong with this example? It accepts all server certificates!

Lesson 3: Always validate the server's certificate

Using self-signed certificates

- *The right way:* Certificate Pinning
  - i.e., hardcode your self-signed certificate.

```java
CertificateFactory cf = CertificateFactory.getInstance("X.509");
// From https://www.washington.edu/itconnect/security/ca/load-der.crt
InputStream caInput = new BufferedInputStream(new FileInputStream("load-der.crt"));
Certificate ca;
try {
    ca = cf.generateCertificate(caInput);
    System.out.println("ca=" + ((X509Certificate) ca).getSubjectDN());
} finally {
    caInput.close();
}
```

Step 1: Read in your certificate

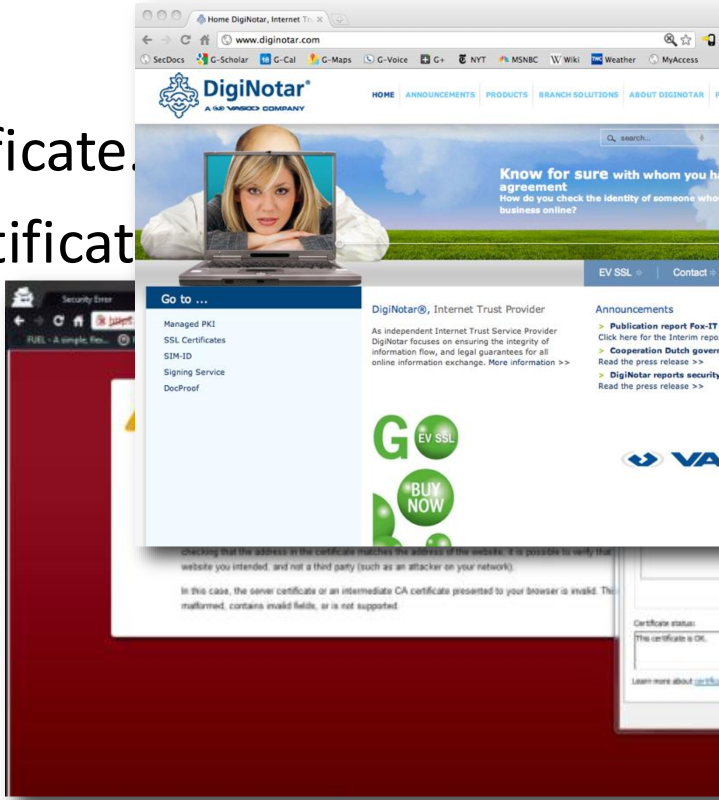
```java
// Create a KeyStore containing our trusted CAs
String keyStoreType = KeyStore.getDefaultType();
KeyStore keyStore = KeyStore.getInstance(keyStoreType);
keyStore.load(null, null);
keyStore.setCertificateEntry("ca", ca);

// Create a TrustManager that trusts the CAs in our KeyStore
String tmfAlgorithm = TrustManagerFactory.getDefaultAlgorithm();
TrustManagerFactory tmf = TrustManagerFactory.getInstance(tmfAlgorithm);
tmf.init(keyStore);

// Create an SSLContext that uses our TrustManager
SSLContext context = SSLContext.getInstance("TLS");
context.init(null, tmf.getTrustManagers(), null);
```

Step 2: Create custom TrustManager

Step 3: Compare server certificate with the hard-coded one ✓ ✗

Using self-signed certificates

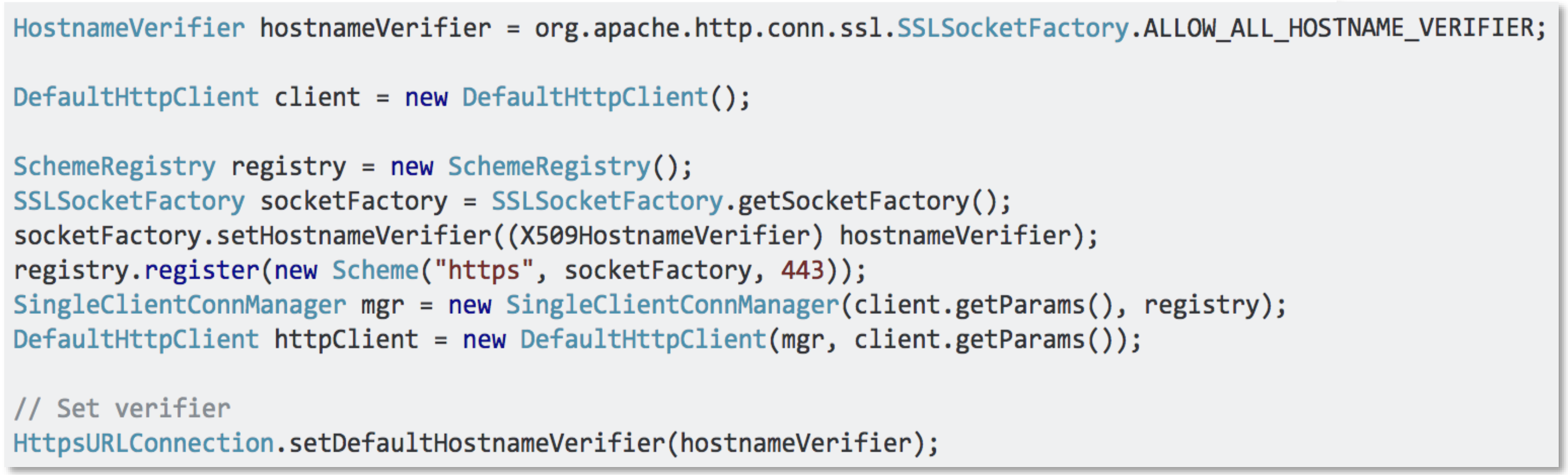
- *The right way:* Certificate Pinning
  - i.e., hardcode your self-signed certificate.
  - Allows *secure* use of self-signed certificat
- Variation:
  - Pinning own CA certificate
  - Gives you more flexibility.
- How to change the certificate?
  - App updates!
- Don't have to trust 100s of Root CAs!



Lesson 4: Certificate pinning, if done correctly, is more secure than *default SSL use.*

Hostname Verification

- Back to basics: What does a certificate provide?
  - Binding between a *public key* and *identity*



```
HostnameVerifier hostnameVerifier = org.apache.http.conn.ssl.SSLSocketFactory.ALLOW_ALL_HOSTNAME_VERIFIER;

DefaultHttpClient client = new DefaultHttpClient();

SchemeRegistry registry = new SchemeRegistry();
SSLSocketFactory socketFactory = SSLSocketFactory.getSocketFactory();
socketFactory.setHostnameVerifier((X509HostnameVerifier) hostnameVerifier);
registry.register(new Scheme("https", socketFactory, 443));
SingleClientConnManager mgr = new SingleClientConnManager(client.getParams(), registry);
DefaultHttpClient httpClient = new DefaultHttpClient(mgr, client.getParams());

// Set verifier
HttpsURLConnection.setDefaultHostnameVerifier(hostnameVerifier);
```

https://stackoverflow.com/questions/2012497/accepting-a-certificate-for-https-on-android?lq=1

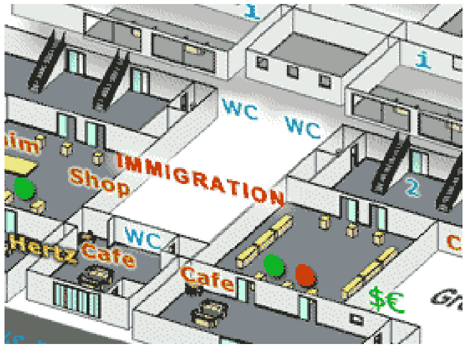
- Any certificate issued by any trusted CA will be accepted!
  - i.e., HostName= google.com, but cert has CN=foogle.com? ✓

Lesson 5: Never override the HostNameVerifier

Access Control

Policy

- A policy specifies the rules of security
  - Some statement of secure procedure or configuration that parameterizes the operation of a system
  - Example: Airport Policy
    - Take off your shoes
    - No bottles that could contain > 3 ozs
    - Empty bottles are OK?
    - You need to put your things through X-ray machine
    - Laptops by themselves, coat off
    - Go through the metal detector



- Goal: prevent on-airplane (metal) weapon, flammable liquid, dangerous objects … (successful?)

Computer Security Policy Goals

- Secrecy
  - Don’t allow reading by unauthorized subjects
  - Control where data can be written by authorized subjects
    - Why is this important?
- Integrity
  - Don’t permit dependence on lower integrity data/code
    - Why is this important?
  - What is “dependence”?
- Availability
  - The necessary function must run
  - Doesn’t this conflict with above?

… when policy goes wrong

- Driving license test: take until you pass
  - Mrs. Miriam Hargrave of Yorkshire, UK failed her driving test 39 times between 1962 and 1970!!!!
  - … she had 212 driving lessons ….
  - She finally got it on the 40th try.
  - Some years later, she was quoted as saying, “sometimes I still have trouble *turning right*”

“A policy is a set of acceptable behaviors.”

- F. Schneider

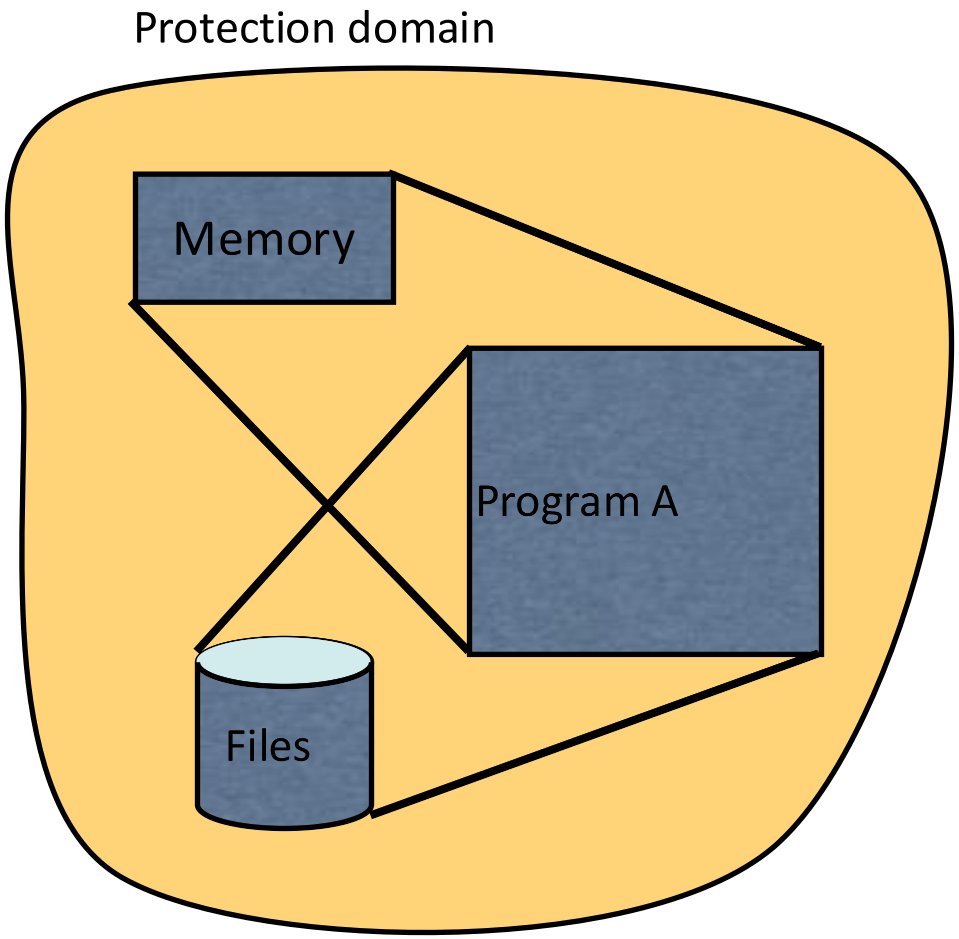
Access Control/Authorization

- An ***access control*** system determines what *rights* a particular *entity/subject* has for a set of *objects*
- It answers the question
  - E.g., do you have the right to read /etc/passwd
  - Does Alice have the right to view the CS website?
  - Do students have the right to share project data?
  - Does Dr. Nadkarni have the right to change your grades?
- An Access Control Policy answers these questions

Simplified Access Control

- Subjects are the active entities that do things
  - E.g., you, Alice, students, Prof. Nadkarni
- Objects are passive things that things are done to
  - E.g., /etc/passwd, CSCI website, project data, grades
- Rights are actions that are taken
  - E.g., read, write, *share*

Protection Domains



- A *protection domain* specifies the set of resources (objects) that a process can access and the operations that the process may use to access such resources.
- How is this done today?
  - Memory protection
  - E.g., UNIX protected memory, file-system permissions (rwx…)

Policy is defined with respect to the protection domain it governs.

Access Policy Enforcement

- A *protection state* defines what each subject can do
  - E.g., in an access bits --- the policy
- A *reference monitor* enforces the protection state
  - A service that responds to the query...
- A correct reference monitor implementation meets the following guarantees
  1. Complete Mediation
  2. Tamperproof
  3. Simple enough to verify
- A *protection system* consists of a (1) protection state, (2) operations to modify that state, and (3) a reference monitor to enforce that state

Trusted Computing Base (TCB)

- The trusted computing base is the infrastructure that you assume will behave correctly
- What do we trust?
  - Hardware (keyboard, monitor, …)
  - Operating Systems
  - Implementations
  - Local networks
  - Administrators
  - Other users on the same system

- Axiom: the larger the TCB, the more assumptions you must make (and hence, the more opportunity to have your assumptions violated).

The Access Matrix

- An access matrix is one way to represent policy.
  - Frequently used mechanism for describing policy
- Columns are objects, subjects are rows.
  - To determine if S_i has right to access object O_j, find the appropriate entry.
  - There is a matrix for each right.
- The access matrix is a succinct descriptor for O(|S|*|O|) rules

	O_1	O_2	O_3
S_1	Y	Y	N
S_2	N	Y	N
S_3	N	Y	Y

The Access Matrix

- Do systems store the entire access control matrix?
- Two ways:
  - Store with the objects (Access control lists (ACL))
  - Store with the subjects (Capability Lists (CL))

	O_1	O_2	O_3
S_1	Y	Y	N
S_2	N	Y	N
S_3	N	Y	Y

Access Control

- Suppose the private key file for J is object O_1
  - Only J can read
- Suppose the public key file for J is object O_2
  - All can read, only J can modify
- Suppose all can read and write from object O_3
- What's the access matrix?

	O_1	O_2	O_3
J	?	?	?
S_2	?	?	?
S_3	?	?	?

Secrecy

- Does the following protection state ensure the secrecy of J's private key in O_1?

	O_1	O_2	O_3
J	R	RW	RW
S_2	-	R	RW
S_3	-	R	RW

Integrity

- Does the following access matrix protect the integrity of J's public key file O_2?

	O_1	O_2	O_3
J	R	RW	RW
S_2	-	R	RW
S_3	-	R	RW

Trusted Processes

- *Does it matter if we do not trust some of J's processes?*
  - *Trojan Horse*: Attacker controlled code run by J can violate secrecy.
  - *Confused Deputy*: Attacker may trick trusted code to violate integrity

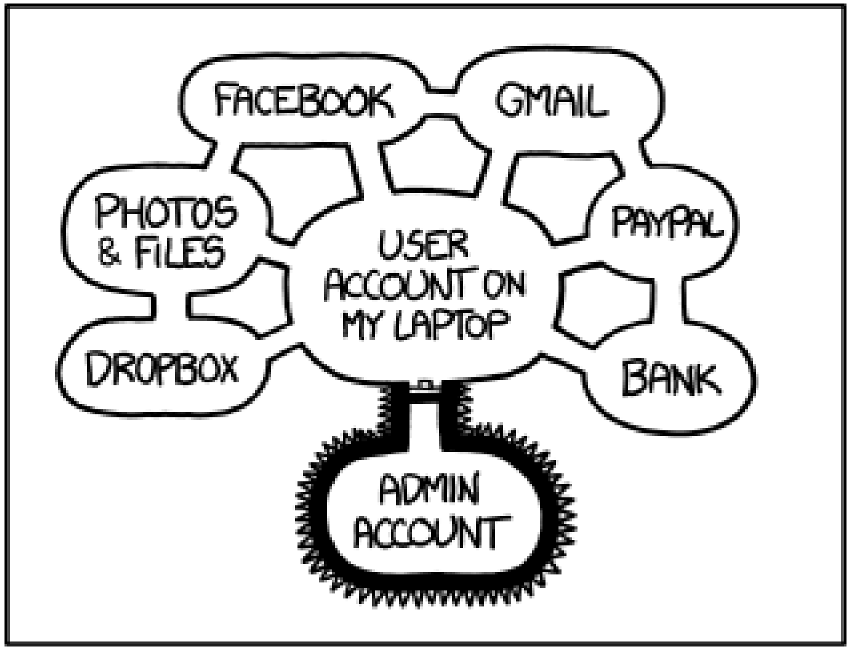
	O_1	O_2	O_3
J	R	RW	RW
S_2	-	R	RW
S_3	-	R	RW

Protection vs. Security

- Protection
  - Security goals met under *trusted* processes
  - Protects against an error by a non-malicious entity
- Security
  - Security goals met under *potentially malicious* processes
  - Protects against any malicious entity
  - Hence, For J:
    - Non-malicious process shouldn’t leak the private key by writing it to O_3
    - A potentially malicious process that may contain a Trojan horse that writes the private key to O_3 should not be able to do so

Do you own a computer?

- Linux/ Windows/ Mac?
- (DONOT) execute everything as the admin user!
  - Create a separate ”standard” user. *Why?*
- Caveat: *Still need to protect the standard user account.*



IF SOMEONE STEALS MY LAPTOP WHILE I'M LOGGED IN, THEY CAN READ MY EMAIL, TAKE MY MONEY, AND IMPERSONATE ME TO MY FRIENDS,

BUT AT LEAST THEY CAN'T INSTALL DRIVERS WITHOUT MY PERMISSION.

Principle of Least Privilege

A system should only provide those rights needed to perform the processes function and no more.

- Implication 1: you want to reduce the protection domain to the smallest possible set of objects
- Implication 2: you want to assign the minimal set of rights to each subject
- Caveat: of course, you need to provide enough rights and a large enough protection domain to get the job done.

Least Privilege

- Limit permissions to those required and no more
  - Restrict privilege of the process of J to prevent leaks
    - Cannot R/W O3

	O_1	O_2	O_3
J	R	RW	-
S_2	-	R	-
S_3	-	R	RW

Conflicting Goals

- Challenges of building a secure system
  - What are the *users*' goals?
  - What do *application developers* want?
  - What about the *data owners* (corporations/governments)?
  - What is the purpose of *system administrators*?
  - What about the requirements of *operating system designers*?
- Need a *satisfying* balance among these goals?

Access Control Administration

There are two central ways to specify a policy

- *Discretionary* - object "owners" define policy
  - Users have discretion over who has access to what objects and when (trusted users)
  - Canonical example: the UNIX filesystem
    - RWX assigned by file owners
- *Mandatory* - Environment enforces static policy
  - Access control policy defined by environment, user has no control over access control (untrusted users)
  - Canonical example: process labeling
    - System assigns labels for processes, objects, and a dominance calculus is used to evaluate rights

DAC vs. MAC

- **<u>Discretionary</u> Access Control**
  - User defines the access policy
  - Can pass rights onto other subjects (called *delegation*)
  - Their programs can pass their rights
    - Consider a Trojan horse
- **<u>Mandatory</u> Access Control**
  - System defines access policy
  - Subjects cannot pass rights
  - Subjects' programs cannot pass rights
    - Consider a Trojan horse here