ECS 235B Module 28
Chinese Wall Model

Chinese Wall Model

Problem:

- Tony advises American Bank about investments
- He is asked to advise Toyland Bank about investments

- Conflict of interest to accept, because his advice for either bank would affect his advice to the other bank

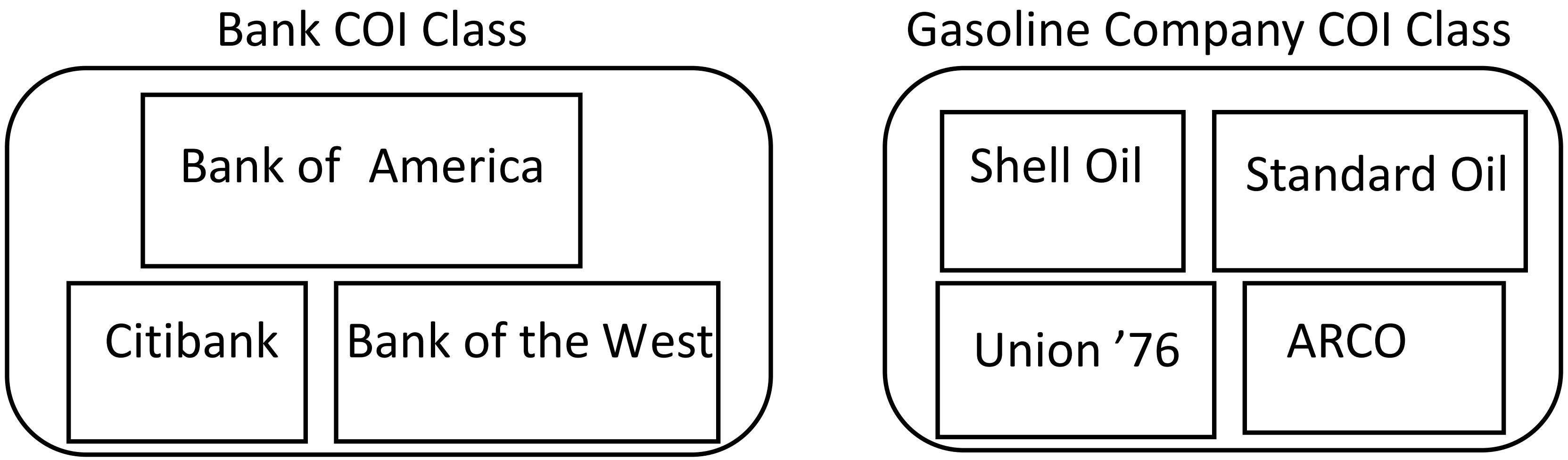
Organization

- Organize entities into “conflict of interest” classes
- Control subject accesses to each class
- Control writing to all classes to ensure information is not passed along in violation of rules
- Allow sanitized data to be viewed by everyone

Definitions

- *Objects*: items of information related to a company
- *Company dataset* (CD): contains objects related to a single company
  - Written *CD*(*O*)
- *Conflict of interest class* (COI): contains datasets of companies in competition
  - Written *COI*(*O*)
  - Assume: each object belongs to exactly one *COI* class

Example



Bank COI Class
Bank of America
Citibank
Bank of the West
Gasoline Company COI Class
Shell Oil
Standard Oil
Union ’76
ARCO

Temporal Element

- If Anthony reads any CD in a COI, he can *never* read another CD in that COI
  - Possible that information learned earlier may allow him to make decisions later
  - Let *PR*(*S*) be set of objects that *S* has already read

CW-Simple Security Condition

- s can read o iff either condition holds:
  1. There is an o' such that s has accessed o' and $CD(o') = CD(o)$
     - Meaning s has read something in o's dataset
  2. For all $o' \in O$, $o' \in PR(s) \Rightarrow COI(o') \neq COI(o)$
     - Meaning s has not read any objects in o's conflict of interest class
- Ignores sanitized data (see below)
- Initially, $PR(s) = \varnothing$, so initial read request granted

Sanitization

- Public information may belong to a CD
  - As is publicly available, no conflicts of interest arise
  - So, should not affect ability of analysts to read
  - Typically, all sensitive data removed from such information before it is released publicly (called *sanitization*)
- Add third condition to CW-Simple Security Condition:

   3. *o* is a sanitized object

Writing

- Anthony, Susan work in same trading house
- Anthony can read Bank 1’s CD, Gas’ CD
- Susan can read Bank 2’s CD, Gas’ CD
- If Anthony could write to Gas’ CD, Susan can read it
  - Hence, indirectly, she can read information from Bank 1’s CD, a clear conflict of interest

CW-*-Property

- *s* can write to *o* iff both of the following hold:
  1. The CW-simple security condition permits *s* to read *o*; and
  2. For all *unsanitized* objects *o*′, if *s* can read *o*′, then *CD*(*o*′) = *CD*(*o*)
- Says that *s* can write to an object if all the (unsanitized) objects it can read are in the same dataset

Formalism

- Goal: figure out how information flows around system
- S set of subjects, O set of objects, $L = C \times D$ set of labels
- l_1: $O \rightarrow C$ maps objects to their COI classes
- l_2: $O \rightarrow D$ maps objects to their CDs
- $H(s, o)$ true iff s has *or had* read access to o
- $R(s, o)$: s's request to read o

Axioms

- Axiom 8-1. For all o, $o' \in O$, if $l_2(o) = l_2(o')$, then $l_1(o) = l_1(o')$
  - CDs do not span COIs.
- Axiom 8-2. $s \in S$ can read $o \in O$ iff, for all $o' \in O$ such that $H(s, o')$, either $l_1(o') \neq l_1(o)$ or $l_2(o') = l_2(o)$
  - *s* can read *o* iff *o* is either in a different COI than every other o' that *s* has read, or in the same CD as *o*.

More Axioms

- Axiom 8-3. $\neg H(s, o)$ for all $s \in S$ and $o \in O$ is an initially secure state
  - Description of the initial state, assumed secure
- Axiom 8-4. If for some $s \in S$ and for all $o \in O$, $\neg H(s, o)$, then any request $R(s, o)$ is granted
  - If s has read no object, it can read any object

Which Objects Can Be Read?

Theorem 8-1: Suppose $s \in S$ has read $o \in O$. If s can read $o' \in O$, $o' \neq o$, then $l_1(o') \neq l_1(o)$ or $l_2(o') = l_2(o)$.

- Says s can read only the objects in a single CD within any COI

Proof

Assume false. Then

$H(s, o) \wedge H(s, o') \wedge l_1(o') = l_1(o) \wedge l_2(o') \neq l_2(o)$

Assume *s* read *o* first. Then $H(s, o)$ when *s* read *o*, so by Axiom 8-2, $l_1(o') \neq l_1(o)$ or $l_2(o') = l_2(o)$, so

$(l_1(o') \neq l_1(\mathrm{o}) \vee l_2(o') = l_2(o)) \wedge (l_1(o') = l_1(o) \wedge l_2(o') \neq l_2(o))$

Rearranging terms,

$(l_1(o') \neq l_1(o) \wedge l_2(o') \neq l_2(o) \wedge l_1(o') = l_1(o)) \vee (l_2(o') = l_2(o) \wedge l_2(o') \neq l_2(o) \wedge l_1(o') = l_1(o))$

which is obviously false, contradiction.

Lemma

Lemma 8-2: Suppose a subject $s \in S$ can read an object $o \in O$. Then s can read no o' for which $l_1(o') = l_1(o)$ and $l_2(o') \neq l_2(o)$.

- So a subject can access at most one CD in each COI class
- Sketch of proof: Initial case follows from Axioms 8-3, 8-4. If $o' \neq o$, theorem immediately gives lemma.

COIs and Subjects

Theorem 8-2: Let $c \in C$. Suppose there are n objects $o_i \in O$, $1 \le i \le n$, such that $l_1(o_i) = c$ for $1 \le i \le n$, and $l_2(o_i) \ne l_2(o_j)$, for $1 \le i, j \le n$, $i \ne j$. Then for all such o, there is an $s \in S$ that can read o iff $n \le |S|$.

- If a COI has n CDs, you need at least n subjects to access every object
- Proof sketch: If s can read o, it cannot read any o' in another CD in that COI (Axiom 8-2). As there are n such CDs, there must be at least n subjects to meet the conditions of the theorem.

Sanitized Data

- $v(o)$: sanitized version of object o
  - For purposes of analysis, place them all in a special CD in a COI containing no other CDs
- Axiom 8-5. $l_1(o) = \mathrm{l}_1(v(o))$ iff $l_2(o) = l_2(v(o))$

Which Objects Can Be Written?

Axiom 8-6. $s \in S$ can write to $o \in O$ iff the following hold simultaneously

1. $H(s, o)$
2. There is no $o' \in O$ with $H(s, o')$, $l_2(o) \neq l_2(o')$, $l_2(o) \neq l_2(v(o))$, $l_2(o') = l_2(v(o))$.

- Allow writing iff information cannot leak from one subject to another through a mailbox
- Note handling for sanitized objects

How Information Flows

Definition: information may flow from o to o' if there is a subject such that $H(s, o)$ and $H(s, o')$.

- Intuition: if s can read 2 objects, it can act on that knowledge; so information flows between the objects through the nexus of the subject
- Write the information flow between o and o' as (o, o')

Key Result

Theorem 8-3: Set of all information flows is

$\{ (o, o') \mid o \in O \wedge o' \in O \wedge l_2(o) = l_2(o') \vee l_2(o) = l_2(v(o)) \}$

Sketch of proof: Definition gives set of flows:

$F = \{(o, o') \mid o \in O \wedge o' \in O \wedge \exists\, s \in S$ such that $H(s, o) \wedge H(s, o'))\}$

Axiom 8-6 excludes the following flows:

$X = \{ (o, o') \mid o \in O \wedge o' \in O \wedge l_2(o) \neq l_2(o') \wedge l_2(o) \neq l_2(v(o)) \}$

So, letting F^* be transitive closure of F,

$F^* - X = \{(o, o') \mid o \in O \wedge o' \in O \wedge \neg(l_2(o) \neq l_2(o') \wedge l_2(o) \neq l_2(v(o))) \}$

which is equivalent to the claim.

Aggressive Chinese Wall Model

- Assumption of Chinese Wall Model: COI classes are actually related to business, and those are partitions
  - Continuing bank and oil company example, the latter may invest in some companies, placing them in competition with banks
  - One bank may only handle savings, and another a brokerage house, so they are not in competition
- More formally: Chinese Wall model assumes the elements of O can be partitioned into COIs, and thence into CDs
  - Define *CIR* to be the conflict of interest relation induced by a COI
  - For $o, o' \in O$, if o, o' are in the same COI, then $(o, o') \in CIR$

The Problem

- Not true in practice!
  - That is, in practice *CIR* does not partition the objects, and so not an equivalence class
  - Example: a company is not in conflict with itself, so $(o, o) \notin CIR$
  - Example: company *c* has its own private savings unit; *b* bank that does both savings and investments; oil company *g* does investments. So $(c, b) \in CIR$ and $(b, g) \in CIR$, but clearly $(c, g) \notin CIR$

The Solution

- Generalize *CIR* to define COIs not based on business classes, so *GCIR* is the reflexive, transitive closure of *CIR*
- To create it:
  - For all $o \in O$, add (o, o) to *CIR*
  - Take the transitive closure of this
- Then (o, o') ∈ *GICR* iff there is an indirect information flow path between o and o'
  - Recall (o, o') ∈ *CIR* iff there is a direct information flow path between o, o'
- Now replace the COIs induced by *CIR* with generalized COIs induced by *GCIR*

Compare to Bell-LaPadula

- Fundamentally different
  - CW has no security labels, Bell-LaPadula does
  - CW has notion of past accesses, Bell-LaPadula does not
- Bell-LaPadula can capture state at any time
  - Each (COI, CD) pair gets security category
  - Two clearances, *S* (sanitized) and *U* (unsanitized)
    - *S dom U*
  - Subjects assigned clearance for compartments without multiple categories corresponding to CDs in same COI class

Compare to Bell-LaPadula

- Bell-LaPadula cannot track changes over time
  - Susan becomes ill, Anna needs to take over
    - C-W history lets Anna know if she can
    - No way for Bell-LaPadula to capture this
- Access constraints change over time
  - Initially, subjects in C-W can read any object
  - Bell-LaPadula constrains set of objects that a subject can access
    - Can’t clear all subjects for all categories, because this violates CW-simple security condition

Compare to Clark-Wilson

- Clark-Wilson Model covers integrity, so consider only access control aspects
- If “subjects” and “processes” are interchangeable, a single person could use multiple processes to violate CW-simple security condition
  - Would still comply with Clark-Wilson Model
- If “subject” is a specific person and includes all processes the subject executes, then consistent with Clark-Wilson Model