OSY.SSI[2018][2]

ACCESS DENIED

In the news...

- THE THREE COLLEGE-AGE defendants behind the the Mirai botnet (...) Josiah White, Paras Jha, and Dalton Norman, who were all between 18 and 20 years old (...) built and launched Mirai (...) which began as a way to attack rival Minecraft videogame hosts.

In the news...

- THE THREE COLLEGE-AGE defendants behind the the Mirai botnet (...) Josiah White, Paras Jha, and Dalton Norman, who were all between 18 and 20 years old (...) built and launched Mirai (...) which began as a way to attack rival Minecraft videogame hosts.
- Peekaboo (CVE-2018-1149, CVE-2018-1150): Hundred thousands of CCTV cameras can be accessed, manipulated, an infected. More than 100 brands affected incl. Sony, Cisco Systems, D-Link and Panasonic. Patch expected next Tuesday...

In the news...

- THE THREE COLLEGE-AGE defendants behind the the Mirai botnet (...) Josiah White, Paras Jha, and Dalton Norman, who were all between 18 and 20 years old (...) built and launched Mirai (...) which began as a way to attack rival Minecraft videogame hosts.
- Peekaboo (CVE-2018-1149, CVE-2018-1150): Hundred thousands of CCTV cameras can be accessed, manipulated, an infected. More than 100 brands affected incl. Sony, Cisco Systems, D-Link and Panasonic. Patch expected next Tuesday...
- ... "It's unfortunate, but each camera will need to be updated manually by users"

In the last episode...

$ · CIA · 50/50 · ×

Insert video here.

All definitions in one little playlet

All definitions in one little playlet

- Computer: What is your name?

All definitions in one little playlet

- Computer: What is your name?
    - This is **identification**.

All definitions in one little playlet

- Computer: What is your name?
  - This is **identification**.
- Computer: Prove it.

All definitions in one little playlet

- Computer: What is your name?
  - This is **identification**.
- Computer: Prove it.
  - This is **authentication**.

All definitions in one little playlet

- Computer: What is your name?
  - This is **identification**.
- Computer: Prove it.
  - This is **authentication**.
- Computer: What is your quest?

All definitions in one little playlet

- Computer: What is your name?
  - This is **identification**.
- Computer: Prove it.
  - This is **authentication**.
- Computer: What is your quest?
  - “To seek the Holy Grail”

All definitions in one little playlet

- Computer: What is your name?
  - This is **identification**.
- Computer: Prove it.
  - This is **authentication**.
- Computer: What is your quest?
  - "To seek the Holy Grail"
- Computer: Let me check if you can do that...

All definitions in one little playlet

- Computer: What is your name?
  - This is **identification**.
- Computer: Prove it.
  - This is **authentication**.
- Computer: What is your quest?
  - “To seek the Holy Grail”
- Computer: Let me check if you can do that...
  - This is **authorization**.

All definitions in one little playlet

- Computer: What is your name?
  - This is **identification**.
- Computer: Prove it.
  - This is **authentication**.
- Computer: What is your quest?
  - “To seek the Holy Grail”
- Computer: Let me check if you can do that...
  - This is **authorization**.
- Computer: Sorry mate, you can’t do this. Access denied.

All definitions in one little playlet

- Computer: What is your name?
  - This is **identification**.
- Computer: Prove it.
  - This is **authentication**.
- Computer: What is your quest?
  - “To seek the Holy Grail”
- Computer: Let me check if you can do that...
  - This is **authorization**.
- Computer: Sorry mate, you can’t do this. Access denied.
  - This is **access control**.

All definitions in one little playlet

- Computer: What is your name?
  - This is **identification**.
- Computer: Prove it.
  - This is **authentication**.
- Computer: What is your quest?
  - "To seek the Holy Grail"
- Computer: Let me check if you can do that...
  - This is **authorization**.
- Computer: Sorry mate, you can't do this. Access denied.
  - This is **access control**.

What could go wrong?

Table of Contents

Access control

Identification and authentication

Formal models: The Bell–LaPadula ACM

Access control

The goal of access control is to provide

- Confidentiality
- Integrity

It is implemented by a low level *reference monitor*.

Access control

The goal of access control is to provide

- Confidentiality
- Integrity

It is implemented by a low level *reference monitor*.

Access control implementations must be **NEAT**

- Non-bypassable
- Evaluable
- Always invoked
- Tamper-proof

ENTER
ENTER
DO NOT ENTER

Access control

AC assumes a form of identifiable causality.

- AC tells what can be done to a resource (data, a system, etc.)

Access control

AC assumes a form of identifiable causality.

- AC tells what can be done to a resource (data, a system, etc.)
- Access is granted or denied based on:

Access control

AC assumes a form of identifiable causality.

- AC tells what can be done to a resource (data, a system, etc.)
- Access is granted or denied based on:
  - Identity (who can...)

Access control

AC assumes a form of identifiable causality.

- AC tells what can be done to a resource (data, a system, etc.)
- Access is granted or denied based on:
  - Identity (who can...)
  - Action (...do what...)

Access control

AC assumes a form of identifiable causality.

- AC tells what can be done to a resource (data, a system, etc.)
- Access is granted or denied based on:
  - Identity (who can...)
  - Action (...do what...)
  - Resource (...on what...)

Access control

AC assumes a form of identifiable causality.

- AC tells what can be done to a resource (data, a system, etc.)
- Access is granted or denied based on:
  - Identity (who can...)
  - Action (...do what...)
  - Resource (...on what...)
  - Context (... and when.)

Access control

AC assumes a form of identifiable causality.

- AC tells what can be done to a resource (data, a system, etc.)
- Access is granted or denied based on:
  - Identity (who can...)
  - Action (...do what...)
  - Resource (...on what...)
  - Context (... and when.)

Example : `chmod`

So far so good

Question: How are *access rights* and *security properties* related?

So far so good

Question: How are *access rights* and *security properties* related?

Not obvious... More on that in a minute!

AC in practice? CBAC vs ACL

- **Capability-based (CBAC):** You are given a token that provides access (think key).
- **Access control lists (ACL):** Access is granted by your presence on a list (think VIP Party!)

Whichever flavour you fancy most, they both rely on

- A certain notion of *identity*
- A form of *authority* in control

Table of Contents

Access control

Identification and authentication

Formal models: The Bell–LaPadula ACM

What is identity?

When Metaphysics meets Science

Strong version: what characterises an individual?

What is identity?

When Metaphysics meets Science

Strong version: what characterises an individual?

- Hard (if fascinating) philosophical problem (self/identity/haecceity/ipseity)...

What is identity?

When Metaphysics meets Science

Strong version: what characterises an individual?

- Hard (if fascinating) philosophical problem (self/identity/haecceity/ipseity)...
- Maybe not the way to get something done...

What is identity?

When Metaphysics meets Science

Strong version: what characterises an individual?

- Hard (if fascinating) philosophical problem (self/identity/haecceity/ipseity)...
- Maybe not the way to get something done...
- What about an imperfect approach?

What is identity?

When Metaphysics meets Science

Strong version: what characterises an individual?

- Hard (if fascinating) philosophical problem (self/identity/haecceity/ipseity)...
- Maybe not the way to get something done...
- What about an imperfect approach?

Weak version: what enables to tell someone from a given group for some time?

What is identity?

When Metaphysics meets Science

Strong version: what characterises an individual?

- Hard (if fascinating) philosophical problem (self/identity/haecceity/ipseity)...
- Maybe not the way to get something done...
- What about an imperfect approach?

Weak version: what enables to tell someone from a given group for some time?

- It suffices for this someone to own (temporarily) something the others don't.

What is identity?

When Metaphysics meets Science

Strong version: what characterises an individual?

- Hard (if fascinating) philosophical problem (self/identity/haecceity/ipseity)...
- Maybe not the way to get something done...
- What about an imperfect approach?

Weak version: what enables to tell someone from a given group for some time?

- It suffices for this someone to own (temporarily) something the others don't.
- We shall call this something the « Secret ».

What is identity?

When Metaphysics meets Science

Strong version: what characterises an individual?

- Hard (if fascinating) philosophical problem (self/identity/haecceity/ipseity)...
- Maybe not the way to get something done...
- What about an imperfect approach?

Weak version: what enables to tell someone from a given group for some time?

- It suffices for this someone to own (temporarily) something the others don't.
- We shall call this something the « Secret ».

Henceforth,

$$\text{Identity} \Leftrightarrow \text{Having the Secret}$$

What's a good secret?

A good secret has the following properties:

What’s a good secret?

A good secret has the following properties:

- **Immarcescibility**

What's a good secret?

A good secret has the following properties:

- **Immarcescibility**: it doesn't change over time

What's a good secret?

A good secret has the following properties:

- **Immarcescibility**: it doesn't change over time
- **Unicity**

What's a good secret?

A good secret has the following properties:

- **Immarcescibility**: it doesn't change over time
- **Unicity**: no one else has the same secret

What's a good secret?

A good secret has the following properties:

- **Immarcescibility**: it doesn't change over time
- **Unicity**: no one else has the same secret
- **Incessibility**

What's a good secret?

A good secret has the following properties:

- **Immarcescibility**: it doesn't change over time
- **Unicity**: no one else has the same secret
- **Incessibility**: the secret cannot be given to anyone else

What's a good secret?

A good secret has the following properties:

- **Immarcescibility**: it doesn't change over time
- **Unicity**: no one else has the same secret
- **Incessibility**: the secret cannot be given to anyone else
- **Inimitability**

What's a good secret?

A good secret has the following properties:

- **Immarcescibility**: it doesn't change over time
- **Unicity**: no one else has the same secret
- **Incessibility**: the secret cannot be given to anyone else
- **Inimitability**: the secret cannot be copied by anyone else.

What's a good secret?

A good secret has the following properties:

- **Immarcescibility**: it doesn't change over time
- **Unicity**: no one else has the same secret
- **Incessibility**: the secret cannot be given to anyone else
- **Inimitability**: the secret cannot be copied by anyone else.
- **Revokability**

What's a good secret?

A good secret has the following properties:

- **Immarcescibility**: it doesn't change over time
- **Unicity**: no one else has the same secret
- **Incessibility**: the secret cannot be given to anyone else
- **Inimitability**: the secret cannot be copied by anyone else.
- **Revokability**: the secret can be destroyed if needed.

What's a good secret?

A good secret has the following properties:

- **Immarcescibility**: it doesn't change over time
- **Unicity**: no one else has the same secret
- **Incessibility**: the secret cannot be given to anyone else
- **Inimitability**: the secret cannot be copied by anyone else.
- **Revokability**: the secret can be destroyed if needed.

Examples ?

What's a good secret?

A good secret has the following properties:

- **Immarcescibility**: it doesn't change over time
- **Unicity**: no one else has the same secret
- **Incessibility**: the secret cannot be given to anyone else
- **Inimitability**: the secret cannot be copied by anyone else.
- **Revokability**: the secret can be destroyed if needed.

Examples ? **Realistic examples**?

What's a good secret?

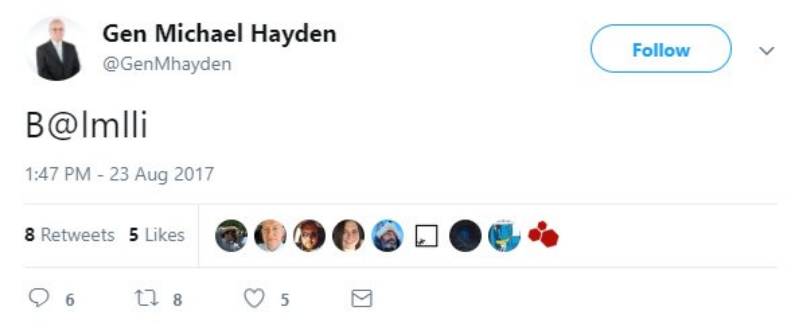
A good secret has the following properties:

- **Immarcescibility**: it doesn't change over time
- **Unicity**: no one else has the same secret
- **Incessibility**: the secret cannot be given to anyone else
- **Inimitability**: the secret cannot be copied by anyone else.
- **Revokability**: the secret can be destroyed if needed.

Examples ? **Realistic examples**?

In short, secrets seem to require... access control themselves.

Aside: Keep secrets secret!



Gen Michael Hayden

@GenMhayden

B@lmlli

1:47 PM - 23 Aug 2017

8 Retweets 5 Likes

Authentication

An *authentication protocol* checks that you indeed know the secret.

Authentication

An *authentication protocol* checks that you indeed know the secret.

Such a protocol should have the following properties:

Authentication

An *authentication protocol* checks that you indeed know the secret.

Such a protocol should have the following properties:

- **Correctness**

Authentication

An *authentication protocol* checks that you indeed know the secret.

Such a protocol should have the following properties:

- **Correctness**: if you have the secret, all goes well.

Authentication

An *authentication protocol* checks that you indeed know the secret.

Such a protocol should have the following properties:

- **Correctness**: if you have the secret, all goes well.

$$\Pr[\mathrm{Auth}_{X,Y}(X) \mid s \in X] = 1 - \mathrm{negl}$$

Authentication

An *authentication protocol* checks that you indeed know the secret.

Such a protocol should have the following properties:

- **Correctness**: if you have the secret, all goes well.

$$\mathrm{Pr}[\mathrm{Auth}_{X,Y}(X) \mid s \in X] = 1 - \mathrm{negl}$$

- **Signifiance**

Authentication

An *authentication protocol* checks that you indeed know the secret.

Such a protocol should have the following properties:

- **Correctness**: if you have the secret, all goes well.

$$\mathrm{Pr}[\mathrm{Auth}_{X,Y}(X) \mid s \in X] = 1 - \mathrm{negl}$$

- **Signifiance**: if all goes well, it means you had the the secret.

Authentication

An *authentication protocol* checks that you indeed know the secret.

Such a protocol should have the following properties:

- **Correctness**: if you have the secret, all goes well.

$$\Pr[\mathrm{Auth}_{X,Y}(X) \mid s \in X] = 1 - \mathrm{negl}$$

- **Signifiance**: if all goes well, it means you had the the secret.

$$\Pr[s \in X \mid \mathrm{Auth}_{X,Y}(X)] = 1 - \mathrm{negl}$$

Authentication

An *authentication protocol* checks that you indeed know the secret.

Such a protocol should have the following properties:

- **Correctness**: if you have the secret, all goes well.

$$\mathrm{Pr}[\mathrm{Auth}_{X,Y}(X) \mid s \in X] = 1 - \mathrm{negl}$$

- **Signifiance**: if all goes well, it means you had the the secret.

$$\mathrm{Pr}[s \in X \mid \mathrm{Auth}_{X,Y}(X)] = 1 - \mathrm{negl}$$

- **Non-transferability**

Authentication

An *authentication protocol* checks that you indeed know the secret.

Such a protocol should have the following properties:

- **Correctness**: if you have the secret, all goes well.

$$\Pr[\mathrm{Auth}_{X,Y}(X) \mid s \in X] = 1 - \mathrm{negl}$$

- **Signifiance**: if all goes well, it means you had the the secret.

$$\Pr[s \in X \mid \mathrm{Auth}_{X,Y}(X)] = 1 - \mathrm{negl}$$

- **Non-transferability**: the transcript cannot be used to authenticate to a third party.

Authentication

An *authentication protocol* checks that you indeed know the secret.

Such a protocol should have the following properties:

- **Correctness**: if you have the secret, all goes well.

$$\Pr[\mathrm{Auth}_{X,Y}(X) \mid s \in X] = 1 - \mathrm{negl}$$

- **Signifiance**: if all goes well, it means you had the the secret.

$$\Pr[s \in X \mid \mathrm{Auth}_{X,Y}(X)] = 1 - \mathrm{negl}$$

- **Non-transferability**: the transcript cannot be used to authenticate to a third party.

$$\Pr[\mathrm{Auth}_{X,Z}(Y) \mid \mathrm{Auth}_{X,Y}(X)] = \mathrm{negl}$$

Examples ?

How to achieve non-transferability?

Any idea?

Zero-knowledge proofs

Fact:

Zero-knowledge proofs

Fact: Zero-knowledge proofs exist.

Zero-knowledge proofs

Fact: Zero-knowledge proofs exist. For many things (all of **NP**).

Zero-knowledge proofs

Fact: Zero-knowledge proofs exist. For many things (all of **NP**).

An example from my magical hat

Exercise: Can you think of another one?

Important distinctions

So we have:

- A **secret** (which is secret)
- An **authentication mechanism** (which is public)
- An **access control policy** (which may be public or not, but better be)

These three things are different and (in principle) independent.

Important distinctions

So we have:

- A **secret** (which is secret)
- An **authentication mechanism** (which is public)
- An **access control policy** (which may be public or not, but better be)

These three things are different and (in principle) independent.

REMEMBER THIS: Separation of policy and mechanism

Table of Contents

Access control

Identification and authentication

Formal models: The Bell–LaPadula ACM

Formal models

The goal of a formal model is to prove security properties.

This becomes necessary as soon as the system becomes large.

Bell and LaPadula designed the first provable AC model.

The Bell-LaPadula Model

The archetypical Access Control

The Bell-LaPadula Model

The archetypical Access Control

- L (MLS lattice) e.g.:

$$\text{unclassified} < \text{classified} < \text{secret} < \text{top secret}$$

The Bell-LaPadula Model

The archetypical Access Control

- L (MLS lattice) e.g.:

$$\text{unclassified} < \text{classified} < \text{secret} < \text{top secret}$$

- O (objects with classification $\in L$)
- S (subjects with clearance $\in L$)
- A (operations, e.g.: r, w, x)

The Bell-LaPadula Model

The archetypical Access Control

- L (MLS lattice) e.g.:

$$\text{unclassified} < \text{classified} < \text{secret} < \text{top secret}$$

- O (objects with classification $\in L$)
- S (subjects with clearance $\in L$)
- A (operations, e.g.: r, w, x)
- **Key idea:** "Good" state + "valid" operation ⇒ "Good" state.

The Bell-LaPadula Model

Valid operations

The Bell-LaPadula Model

Valid operations

- *no read-up*: a subject can only read *lower*-level objects ;

The Bell-LaPadula Model

Valid operations

- *no read-up*: a subject can only read *lower*-level objects ;
- *no write down*: a subject can only write objects to *higher* levels

The Bell-LaPadula Model

Valid operations

- *no read-up*: a subject can only read *lower*-level objects ;
- *no write down*: a subject can only write objects to *higher* levels

Bell, LaPadula, Schell for the U.S. Department of Defense (DoD).

The Bell-LaPadula Model

Valid operations

- *no read-up*: a subject can only read *lower*-level objects ;
- *no write down*: a subject can only write objects to *higher* levels

Bell, LaPadula, Schell for the U.S. Department of Defense (DoD).

The Bell-LaPadula Model

Valid operations

- *no read-up*: a subject can only read *lower*-level objects ;
- *no write down*: a subject can only write objects to *higher* levels

Bell, LaPadula, Schell for the U.S. Department of Defense (DoD).

Everything can be formulated as a formal automaton and checked. It's elegant, it's simple, it's fast, it's used all over.

The Bell-LaPadula Model

Valid operations

- *no read-up*: a subject can only read *lower*-level objects ;
- *no write down*: a subject can only write objects to *higher* levels

Bell, LaPadula, Schell for the U.S. Department of Defense (DoD).

Everything can be formulated as a formal automaton and checked. It's elegant, it's simple, it's fast, it's used all over.

Question:

The Bell-LaPadula Model

Valid operations

- *no read-up*: a subject can only read *lower*-level objects ;
- *no write down*: a subject can only write objects to *higher* levels

Bell, LaPadula, Schell for the U.S. Department of Defense (DoD).

Everything can be formulated as a formal automaton and checked. It's elegant, it's simple, it's fast, it's used all over.

Question: Does it work?

The Bell-LaPadula Model

Some limitations...

The Bell-LaPadula Model

Some limitations...

- Integrity, availability... not even taken into account

The Bell-LaPadula Model

Some limitations...

- Integrity, availability... not even taken into account
- Assumes security clearance and classification do not change

The Bell-LaPadula Model

Some limitations...

- Integrity, availability... not even taken into account
- Assumes security clearance and classification do not change
- No clear separation between mechanism and policy

The Bell-LaPadula Model

Some limitations...

- Integrity, availability... not even taken into account
- Assumes security clearance and classification do not change
- No clear separation between mechanism and policy
- Assumes that a state with no confidentiality is a “good” state

The Bell-LaPadula Model

Some limitations...

- Integrity, availability... not even taken into account
- Assumes security clearance and classification do not change
- No clear separation between mechanism and policy
- Assumes that a state with no confidentiality is a “good” state
- Top-secret attractor, unless exceptions introduced

The Bell-LaPadula Model

Some limitations...

- Integrity, availability... not even taken into account
- Assumes security clearance and classification do not change
- No clear separation between mechanism and policy
- Assumes that a state with no confidentiality is a “good” state
- Top-secret attractor, unless exceptions introduced
- Worst of all: doesn’t even do the job about confidentiality...

The Bell-LaPadula Model

Some limitations...

- Integrity, availability... not even taken into account
- Assumes security clearance and classification do not change
- No clear separation between mechanism and policy
- Assumes that a state with no confidentiality is a “good” state
- Top-secret attractor, unless exceptions introduced
- Worst of all: doesn’t even do the job about confidentiality...

Do you see why?

Hidden channel!

There is a *hidden* channel in the BLP model.

Hidden channel!

There is a *hidden* channel in the BLP model.
Worse: there is no *provable* way around it in general (Shannon, Turing).

Hidden channel!

There is a *hidden* channel in the BLP model.
Worse: there is no *provable* way around it in general (Shannon, Turing).
Dilemma: *expressive* AC *vs. correct* AC.

Hidden channel!

There is a *hidden* channel in the BLP model.
Worse: there is no *provable* way around it in general (Shannon, Turing).
Dilemma: *expressive* AC *vs.* *correct* AC.

BLP crime: confusing policy and mechanism

Information flow?

Question: can *information flow* be blocked?

Information flow?

Question: can *information flow* be blocked? Can it be blocked selectively ?

Information flow?

Question: can *information flow* be blocked? Can it be blocked selectively ?

More about that in a later lecture!

P *clap* A *clap* U *clap* S *clap* E

Send me CVs • Ask questions • Brush your teeth