Access Control: Authorization (Part II)

It used to be expensive to make things public and cheap to make them private. Now it's expensive to make things private and cheap to make them public.

— Clay Shirky, Internet scholar and professor at N.Y.U.

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Outline

- Introduction
- Lampson's Access Control Matrix
- Access Control Lists (ACLs)
- Capabilities (or C-Lists)
- CAPTCHA
- Firewalls
- Packets Filters

Authentication vs Authorization

- Authentication — Are you who you say you are?
  - Restrictions on who (or what) can access system
- **Authorization** — Are you allowed to do that?
  - Restrictions on actions of authenticated users
- Authorization is a form of **access control**
- But first, we look at system certification…

Authentication vs Authorization

- Authentication — Are you who you say you are?
  - Restrictions on who (or what) can access system
- **Authorization** — Are you allowed to do that?
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- Authorization is a form of **access control**
- Classic authorization enforced by
  - Access Control Lists (ACLs)
  - Capabilities (C-lists)

Lampson's Access Control Matrix

- **Subjects** (users) index the rows
- **Objects** (resources) index the columns

	OS	Accounting program	Accounting data	Insurance data	Payroll data
Bob	rx	rx	r	---	---
Alice	rx	rx	r	rw	rw
Sam	rwx	rwx	r	rw	rw
Accounting program	rx	rx	rw	rw	rw

Are You Allowed to Do That?

- **Access control matrix** has **all** relevant info
- Could be 1000's of users, 1000's of resources
- Then matrix with 1,000,000's of entries
- How to manage such a large matrix?
- Need to check this matrix before access to any resource is allowed
- How to make this efficient?

Access Control Lists (ACLs)

- ACL: store access control matrix by **column**
- Example: ACL for **insurance data** is in **blue**

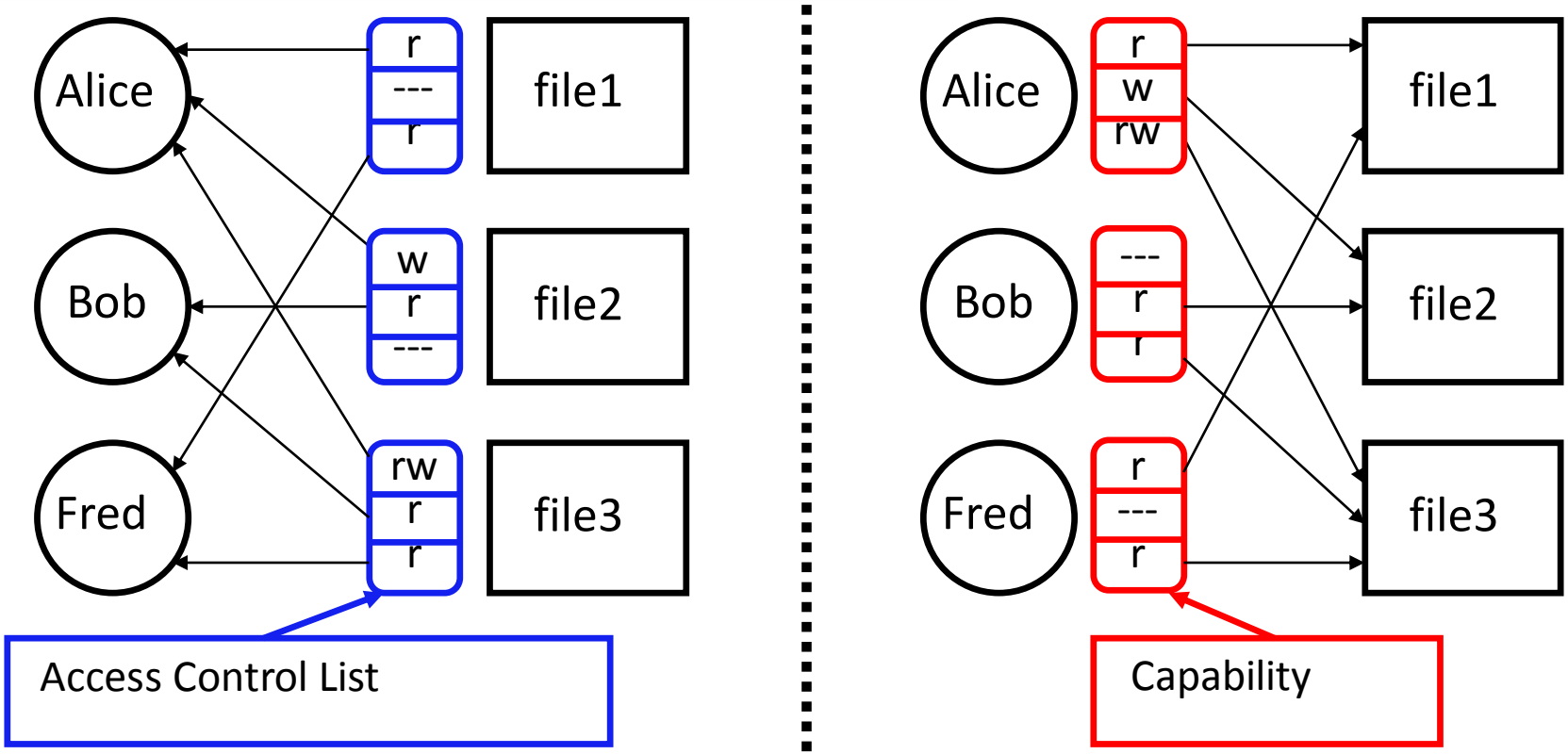
	OS	Accounting program	Accounting data	**Insurance data**	Payroll data
Bob	rx	rx	r	---	---
Alice	rx	rx	r	rw	rw
Sam	rwx	rwx	r	rw	rw
Accounting program	rx	rx	rw	rw	rw

Capabilities (or C-Lists)

- Store access control matrix by **row**
- Example: Capability for **Alice** is in **red**

	OS	Accounting program	Accounting data	Insurance data	Payroll data
Bob	rx	rx	r	---	---
Alice	rx	rx	r	rw	rw
Sam	rwx	rwx	r	rw	rw
Accounting program	rx	rx	rw	rw	rw

ACLs vs Capabilities



- Note that arrows point in opposite directions…
- With ACLs, still need to associate users to files

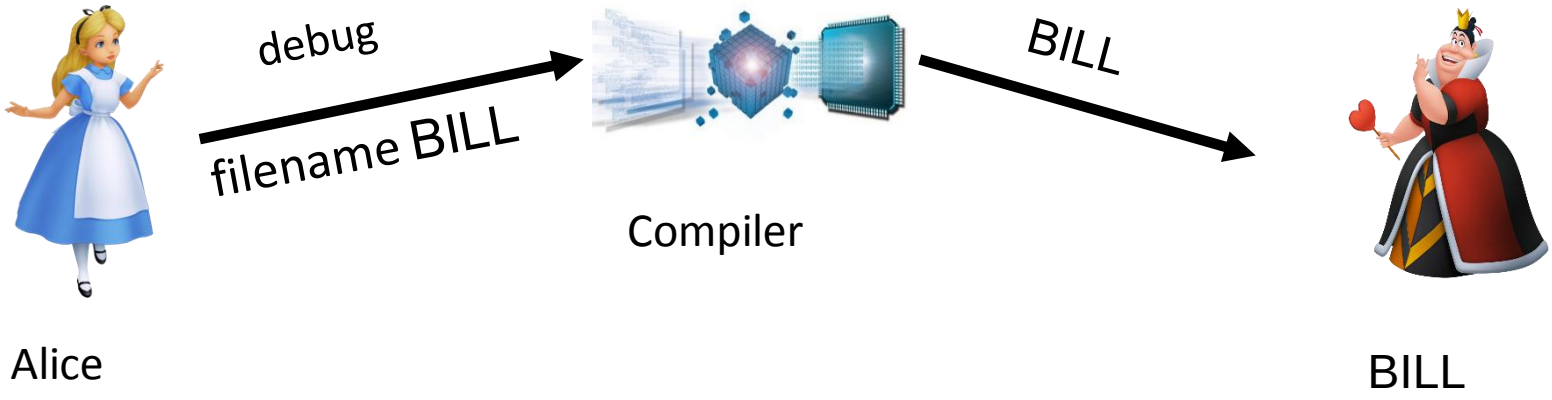
Confused Deputy

- Two resources
  - Compiler and BILL file (billing info)
- Compiler can write file BILL
- Alice can invoke compiler with a debug filename
- Alice not allowed to write to BILL

- Access control matrix

	Compiler	BILL
Alice	x	---
Compiler	rx	rw

ACL's and Confused Deputy



- Compiler is **deputy** acting on behalf of Alice
- Compiler is **confused**
  - Alice is not allowed to write BILL
- Compiler has confused its rights with Alice's

Confused Deputy

- Compiler acting for Alice is confused
- There has been a separation of **authority** from the **purpose** for which it is used
- With ACLs, difficult to avoid this problem
- With Capabilities, easier to prevent problem
  - Must maintain association between authority and intended purpose
  - Capabilities make it easy to **delegate** authority

ACLs vs Capabilities

- ACLs
  - Good when users manage their own files
  - Protection is data-oriented
  - Easy to change rights to a resource
- Capabilities
  - Easy to delegate---avoid the confused deputy
  - Easy to add/delete users
  - More difficult to implement
  - The "Zen of information security"
- Capabilities loved by academics
  - Capability Myths Demolished

CAPTCHA

Turing Test

- Proposed by Alan Turing in 1950
- Human asks questions to another human and a computer, without seeing either
- If questioner cannot distinguish human from computer, computer passes the test
- The **gold standard** in artificial intelligence
- No computer can pass this today
  - But some claim to be close to passing

CAPTCHA

- **CAPTCHA**
  - **C**ompletely **A**utomated **P**ublic **T**uring test to tell **C**omputers and **H**umans **A**part
- **A**utomated — test is generated and scored by a computer program
- **P**ublic — program and data are public
- **T**uring test to tell… — humans can pass the test, but machines cannot pass
  - Also known as **HIP** == **H**uman **I**nteractive **P**roof
- Like an inverse Turing test (well, sort of…)

CAPTCHA Paradox?

- "…CAPTCHA is a program that can generate and grade tests that it itself cannot pass…"
  - "…much like some professors…"
- Paradox — computer creates and scores test that it cannot pass!
- CAPTCHA used so that only humans can get access (i.e., no bots/computers)
- CAPTCHA is for **access control**

CAPTCHA Uses?

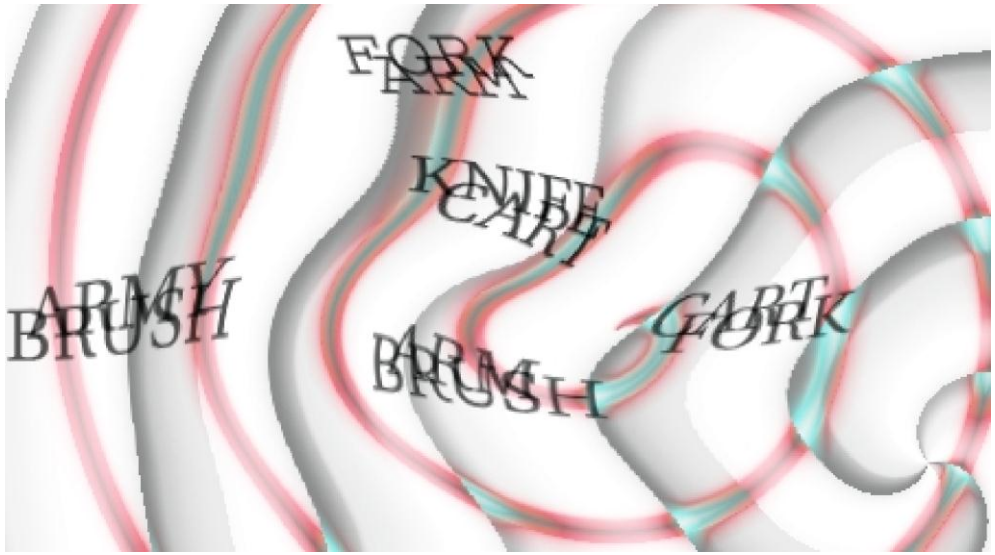
- Original motivation: automated bots stuffed ballot box in vote for best CS grad school
  - SJSU vs Stanford?
- Free email services — spammers like to use bots to sign up for 1000's of email accounts
  - CAPTCHA employed so only humans get accounts
- Sites that do not want to be automatically indexed by search engines
  - CAPTCHA would force human intervention

CAPTCHA: Rules of the Game

- Easy for most humans to pass
- Difficult or impossible for machines to pass
  - **Even with access to CAPTCHA software**
- From Trudy's perspective, the only unknown is a random number
  - Analogous to Kerckhoffs' Principle
- Desirable to have different CAPTCHAs in case some person cannot pass one type
  - Blind person could not pass visual test, etc.

Do CAPTCHAs Exist?

- Test: Find 2 words in the following



  - Easy for most humans
  - A (difficult?) OCR problem for computer
    - OCR == Optical Character Recognition

CAPTCHAs

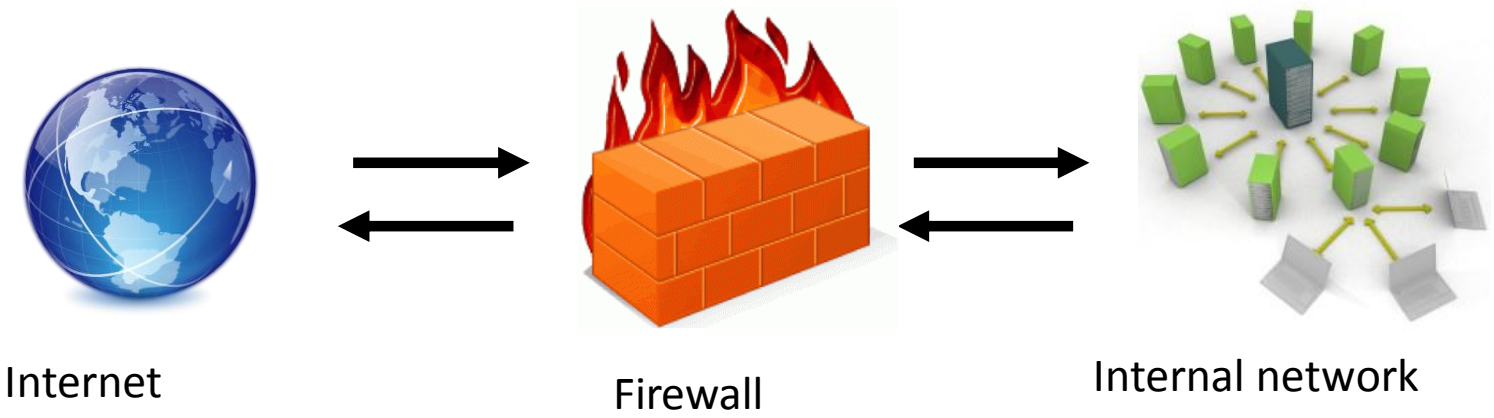
- Current types of CAPTCHAs
  - Visual — like previous example
  - Audio — distorted words or music
- No text-based CAPTCHAs
  - Maybe this is impossible…

CAPTCHA's and AI

- OCR is a challenging AI problem
  - Hard part is the **segmentation problem**
  - Humans good at solving this problem
- Distorted sound makes good CAPTCHA
  - Humans also good at solving this
- Hackers who break CAPTCHA have solved a hard AI problem
  - So, putting hacker's effort to good use!
- Other ways to defeat CAPTCHAs???

Firewalls

Firewalls



- Firewall decides what to let in to internal network and/or what to let out
- **Access control** for the network

Firewall as Secretary

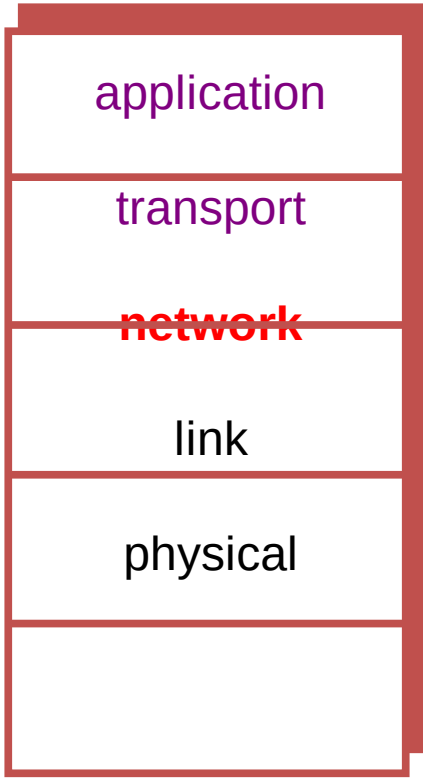
- A firewall is like a **secretary**
- To meet with an executive
  - First contact the secretary
  - Secretary decides if meeting is important
  - So, secretary filters out many requests
- You want to meet chair of CS department?
  - Secretary does some filtering
- You want to meet the POTUS?
  - Secretary does lots of filtering

Firewall Terminology

- No standard firewall terminology
- Types of firewalls
  - **Packet filter** — works at network layer
  - **Stateful packet filter** — transport layer
  - **Application proxy** — application layer
- Other terms often used
  - E.g., “deep packet inspection”

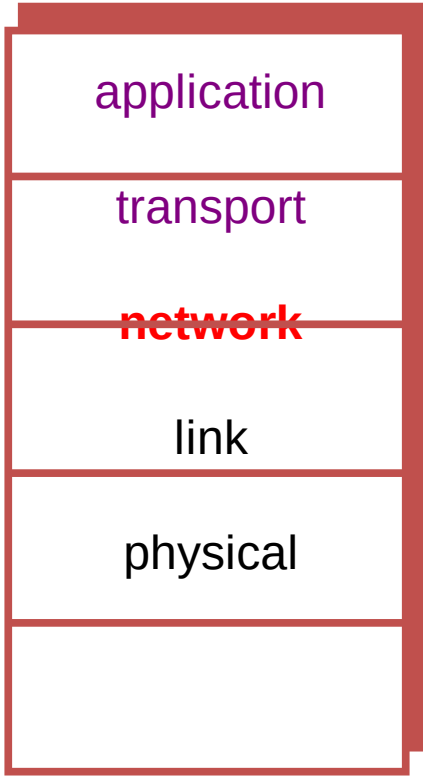
Packet Filter

- Operates at network layer
- Can filters based on…
  - Source IP address
  - Destination IP address
  - Source Port
  - Destination Port
  - Flag bits (SYN, ACK, etc.)
  - Egress or ingress



Packet Filter

- Advantages?
  - Speed
- Disadvantages?
  - No concept of state
  - Cannot see TCP connections
  - Blind to application data



Packet Filter

- Configured via Access Control Lists (ACLs)

Action	Source IP	Dest IP	Source Port	Dest Port	Protocol	Flag Bits
Allow	Inside	Outside	Any	80	HTTP	Any
Allow	Outside	Inside	80	> 1023	HTTP	ACK
Deny	All	All	All	All	All	All

- **Q**: Intention?
- **A**: Restrict traffic to Web browsing

Authorization

- Authorization — are you allowed to do that?
  - Access control matrix/ACLs/Capabilities
  - CAPTCHA
  - Firewalls