CSCI 667:
Concepts of Computer Security

Lecture 2

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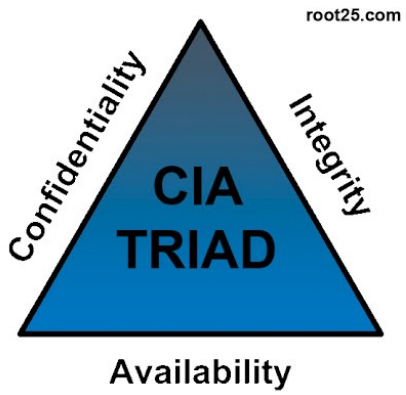
Derived from slides by William Enck, Micah Sherr and Patrick McDaniel

What is security?

- Garfinkel and Spafford (1991)
  - "A computer is secure if you can depend on it and its software to behave as expected."
- Harrison, Ruzzo, Ullman (1978)
  - "Prevent access by unauthorized users"
- Not really satisfactory – does not truly capture that security speaks to the behavior of others
  - Expected by whom?
  - Under what circumstances?

Security Goals

- *Confidentiality*: Prevention of unauthorized disclosure of information
- *Integrity*: Prevention of unauthorized modification of information
- *Availability*: Prevention of unauthorized withholding of information or resources



Brinkley and Schell, "Concepts and Terminology for Computer Security."

Security Goals (continued)

- *Authenticity*: Related to integrity, but also speaks to the sender, as well as freshness
- *Secrecy*: Similar to confidentiality, but often used when discussing specific mechanisms, e.g., access control
- *Non-repudiation*: Prevent a party from denying that some action took place
- *Privacy*: The ability/right to control access to one's information. There are many definitions. Often conflated with confidentiality/secrecy.

Risk

- *Assets* are valued resources that can be misused
  - Monetary, data (loss or integrity), time, confidence, trust
- *Risk* is the potential for an asset to be misused
  - Many different formulas, e.g., (Risk = likelihood * impact)
  - What does being misused mean?
    - Privacy (personal)
    - Confidentiality (communication)
    - Integrity (personal or communication)
    - Availability (existential or fidelity)
- Q: What is at stake in your life?

Threats

- A *threat* is a specific means by which an attacker can put a system at risk
  - An ability/goal of an attacker (e.g., eavesdrop , fraud, access denial)
  - Independent of what can be compromised
- A *threat model* is a collection of threats that deemed important for a particular environment
  - A collection of attacker(s) abilities
  - E.g., A powerful attacker can read and modify all communications and generate messages on a communication channel

Vulnerabilities (attack vectors)

- A *vulnerability* is a systematic artifact that exposes the user, data, or system to a threat
- E.g., buffer-overflow, WEP key leakage
- What is the source of a vulnerability?
  - Bad software (or hardware)
  - Bad design, requirements
  - Bad policy/configuration
  - System Misuse
  - Unintended purpose or environment
    - E.g., student IDs for liquor store

Adversary

- An *adversary* is any entity trying to circumvent the security infrastructure (sometimes called *attacker*)
  - The curious and otherwise generally clueless (e.g., script-kiddies)
  - Casual attackers seeking to understand systems
  - Venal people with an ax to grind
  - Malicious groups of largely sophisticated users (e.g, chaos clubs)
  - Competitors (industrial espionage)
  - Governments (seeking to monitor activities)

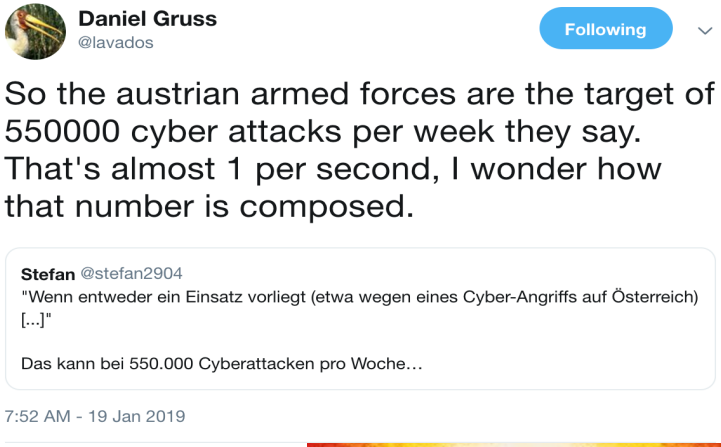
Are users adversaries?

This is known as the insider adversary!

- Have you ever tried to circumvent the security of a system you were authorized to access?
- Have you ever violated a security policy (knowingly or through carelessness)?

Attacks

- An attack occurs when someone attempts to exploit a vulnerability
- Kinds of attacks
  - **Passive** (e.g., eavesdropping)
  - **Active** (e.g., password guessing)
  - **Denial of Service** (DOS)
    - Distributed DOS – using many endpoints



- A compromise occurs when an attack is successful
  - Typically associated with taking over/altering resources

Participants

- *Participants* are expected system entities
  - Computers, agents, people, enterprises, …
  - Depending on context referred to as: servers, clients, users, entities, hosts, routers, …
  - Security is defined with respect to these entites
    - Implication: every party may have unique view
- A *trusted third party*
  - Trusted by all parties for some set of actions
  - Often used as introducer or arbiter

Trust

- *Trust* refers to the degree to which an entity is expected to behave
- What the entity not expected to do?
  - E.g., not expose password
- What the entity is expected to do (obligations)?
  - E.g., obtain permission, refresh
- A *trust model* describes, for a particular environment, who is trusted to do what?
- Note: you make trust decisions every day
  - Q: What are they?
  - Q: Whom do you trust?

Trusted vs. Trustworthy

- *Trusted*: a trusted system or component is one whose failure can break the security policy
- *Trustworthy*: a trusted system or component is one that won't fail

Anderson, "Security Engineering."

Security Model

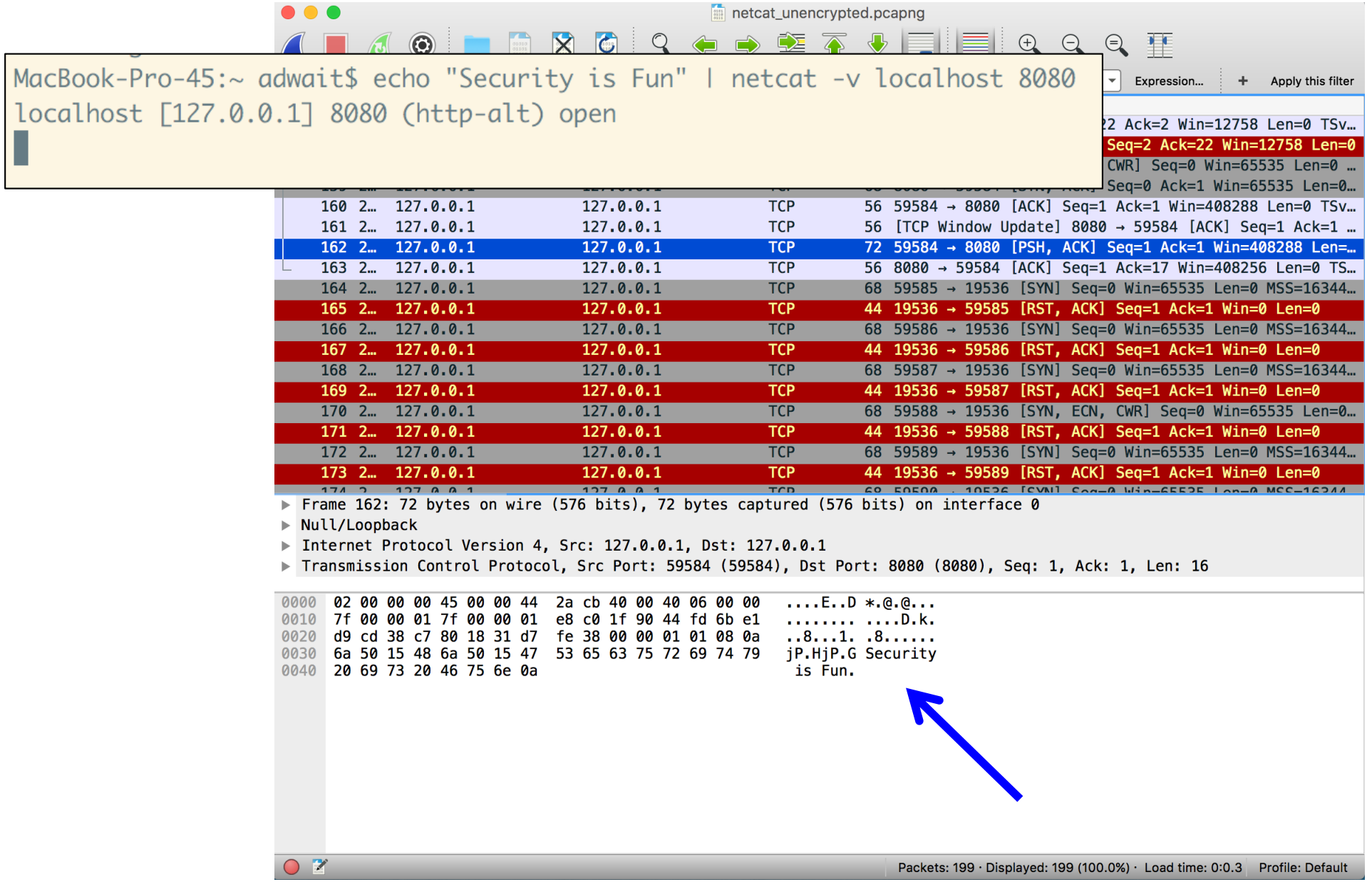
- A *security model* is the combination of a trust and threat models that address the set of perceived risks
  - The "security requirements" used to develop some cogent and comprehensive design
  - Every design must have security model
    - LAN network or global information system
    - Java applet or operating system
- The single biggest mistake seen in use of security is the lack of a coherent security model
  - It is very hard to retrofit security (design time)
- This class is going to talk a lot about security models
  - What are the security concerns (risks)?
  - What are the threats?
  - Who are our adversaries?
  - Who do we trust and to do what?
- Systems must be explicit about these things to be secure.

Cryptography

Why is crypto useful?

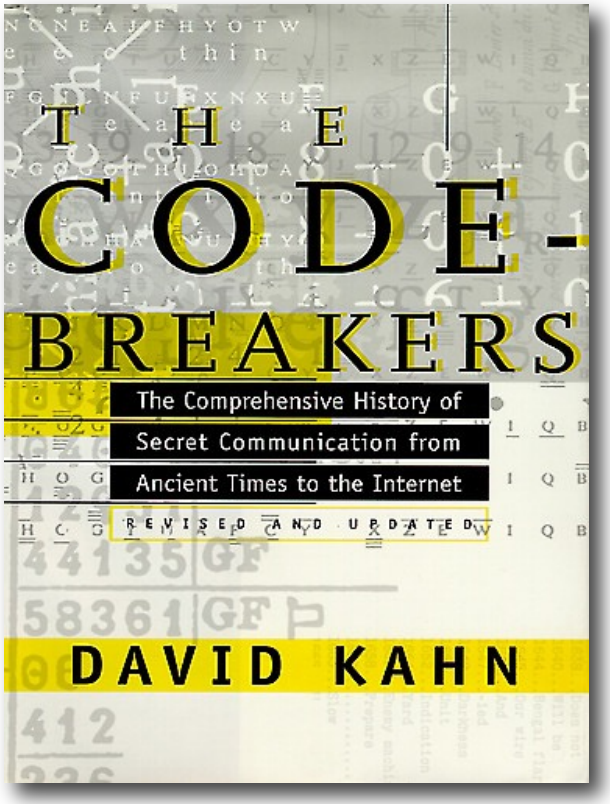
- Networks designed for data transport, not for data confidentiality or privacy
- Internet eavesdropping is (relatively) easy
- Crypto enables:
  - e-commerce and e-banking
  - confidential messaging
  - digital identities
  - protection of personal data
  - electronic voting
  - anonymity

Why is crypto useful?



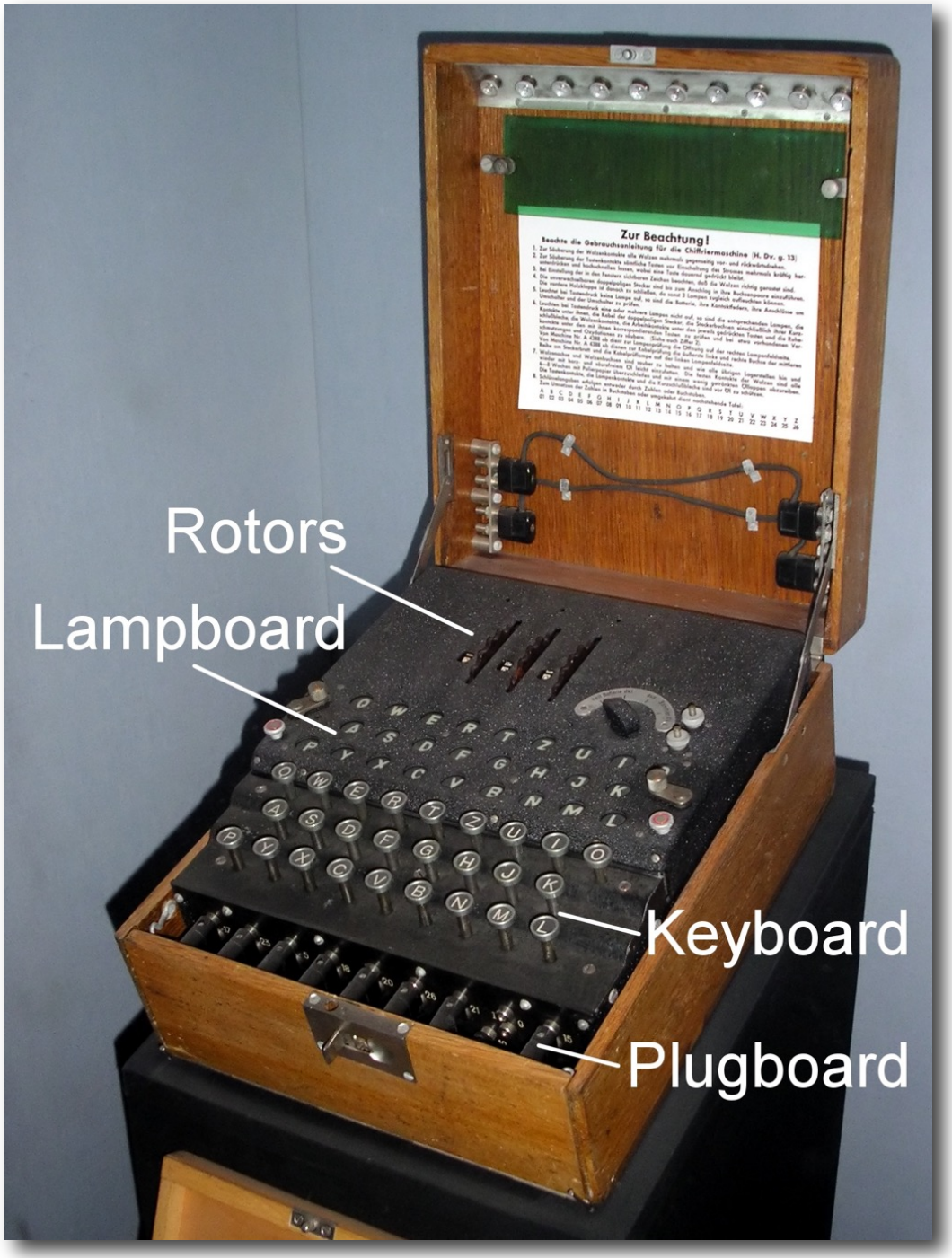
Cryptographic History

- hide secrets from your enemy
- ~4000 year old discipline
  - Egyptians' use of non-standard hieroglyphics
  - Spartans used *scytale* to perform transposition cipher
  - Italian Leon Battista Alberti ("father of western cryptography") invents polyalphabetic ciphers in 1466



Enigma

- German WWII encryption device
- Used polyalphabetic substitution cipher
- Broken by Allied forces
- Intelligence called Ultra
- Codebreaking at Bletchley Park
- See original at the International Spy Museum (bring your wallet)



Some terminology

- **cryptosystem**: method of disguising (encrypting) plaintext messages so that only select parties can decipher (decrypt) the ciphertext
- **cryptography**: the art/science of developing and using cryptosystems
- **cryptanalysis**: the art/science of breaking cryptosystems
- **cryptology**: the combined study of cryptography and cryptanalysis

What can crypto do?

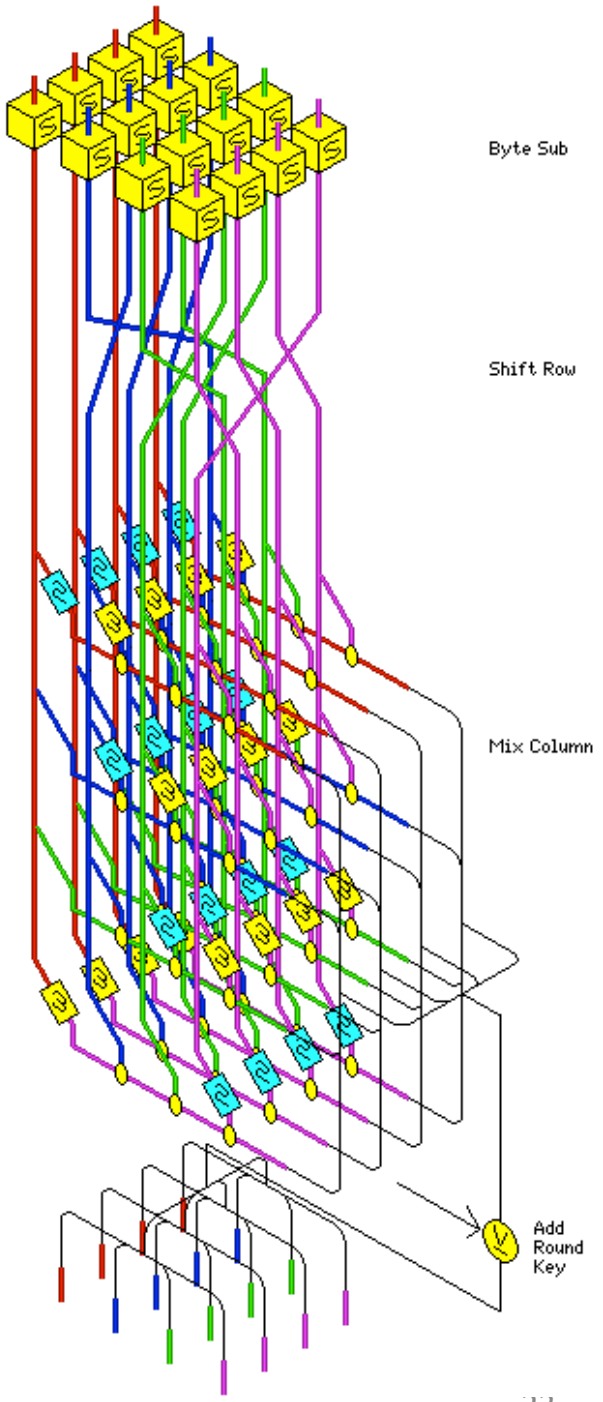
- **Confidentiality**
  - Keep data and communication secret
  - Encryption / decryption
- **Integrity**
  - Protect reliability of data against tampering
  - "Was this the original message that was sent?"
- **Authenticity**
  - Provide evidence that data/messages are from their purported originators
  - "Did Alice really send this message?"

cryptography < security

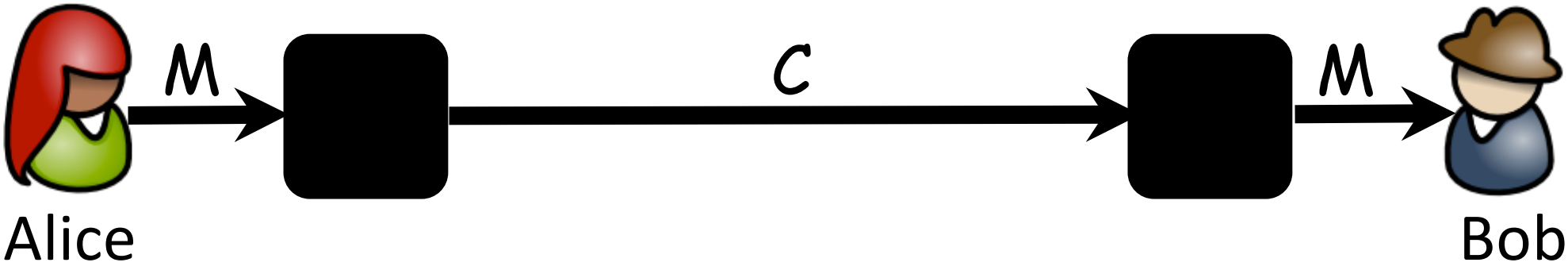
- Cryptography isn't the solution to security
  - Buffer overflows, worms, viruses, trojan horses, SQL injection attacks, cross-site scripting, bad programming practices, etc.
- It's a tool, not a solution
- Even when used, difficult to get right
  - Choice of encryption algorithms
  - Choice of parameters
  - Implementation
  - Hard to detect errors
    - Even when crypto fails, the program may still work
    - May not learn about crypto problems until after they've been exploited

Crypto is really, really, really, really, hard

- Task: develop a cryptosystem that is secure against all conceivable (and inconceivable) attacks, and will be for the foreseeable future
- If you are inventing your own crypto, you're doing it wrong
- Common security idiom: "no one ever got fired for using AES"



Encryption and Decryption



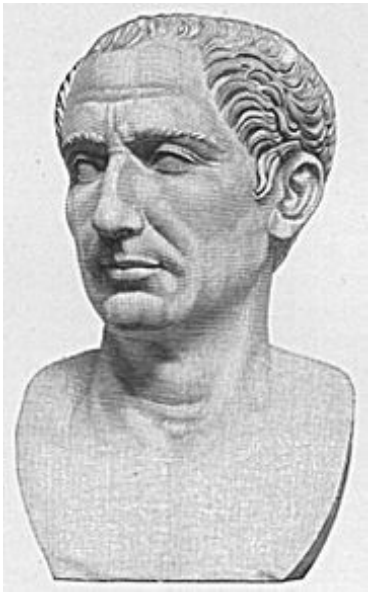
C=E(M)
M=D(C)
i.e.,
M=D(E(M))

where

M = plaintext
C = ciphertext
E(x) = encryption function
D(y) = decryption function

Let's look at some old crypto algos (don't use these)

Caesar Cipher



- A.K.A. Shift Cipher or ROT-x cipher (e.g., ROT-13)
- Used by Julius to communicate with his generals
- x is the key:
- Encryption: Right-shift every character by x: $c = E(x, p) = (p + x) \bmod 26$
- Decryption: Left-shift every character by x: $p = D(x, c) = (c - x) \bmod 26$

S E C U R I T Y A N D P R I V A C Y

V H F X U L W B D Q G S U L Y D F B

The End