Encryption Algorithms & Protocols

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References & textbook:

- Information Security: Principles and Practices, Mark Stamp, J.Wiley & sons; 2 edition ,2011.

- Computer Security Principles and Practice, William Stallings & Lawrie Brown; Third Edition, 2015.

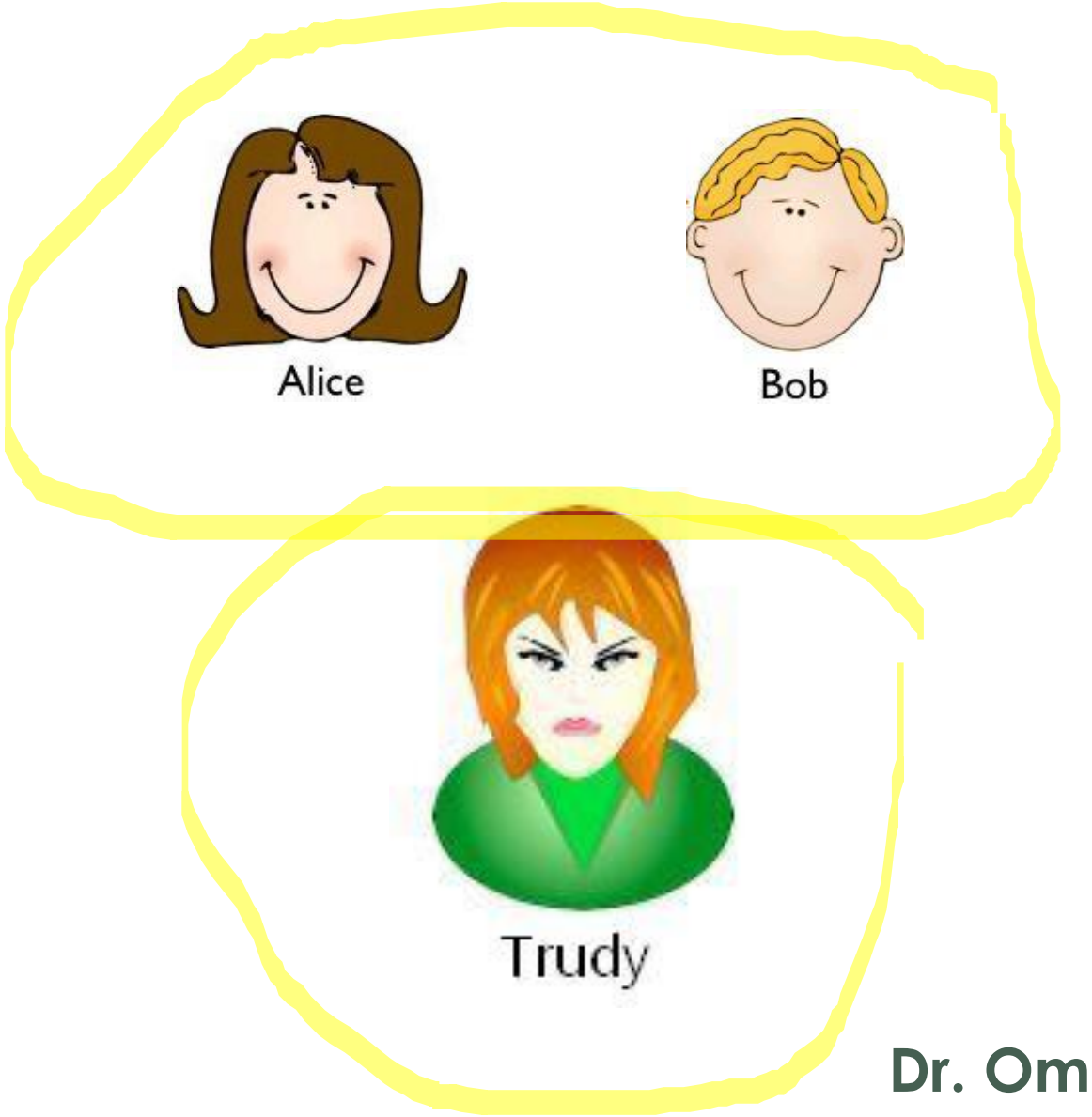
Course Outline

This module consists of

- An introduction to classical & modern cryptography and network security.
- The concepts of block ciphers and message authentication codes.
- Public key encryption, digital signatures, and key establishment.
- How cryptographic algorithms and protocols work.
- As well as common examples and uses of such schemes.

Introduction

- Alice and Bob are the good guys.



- Trudy is the bad “guy”.
- Trudy is our generic “intruder”

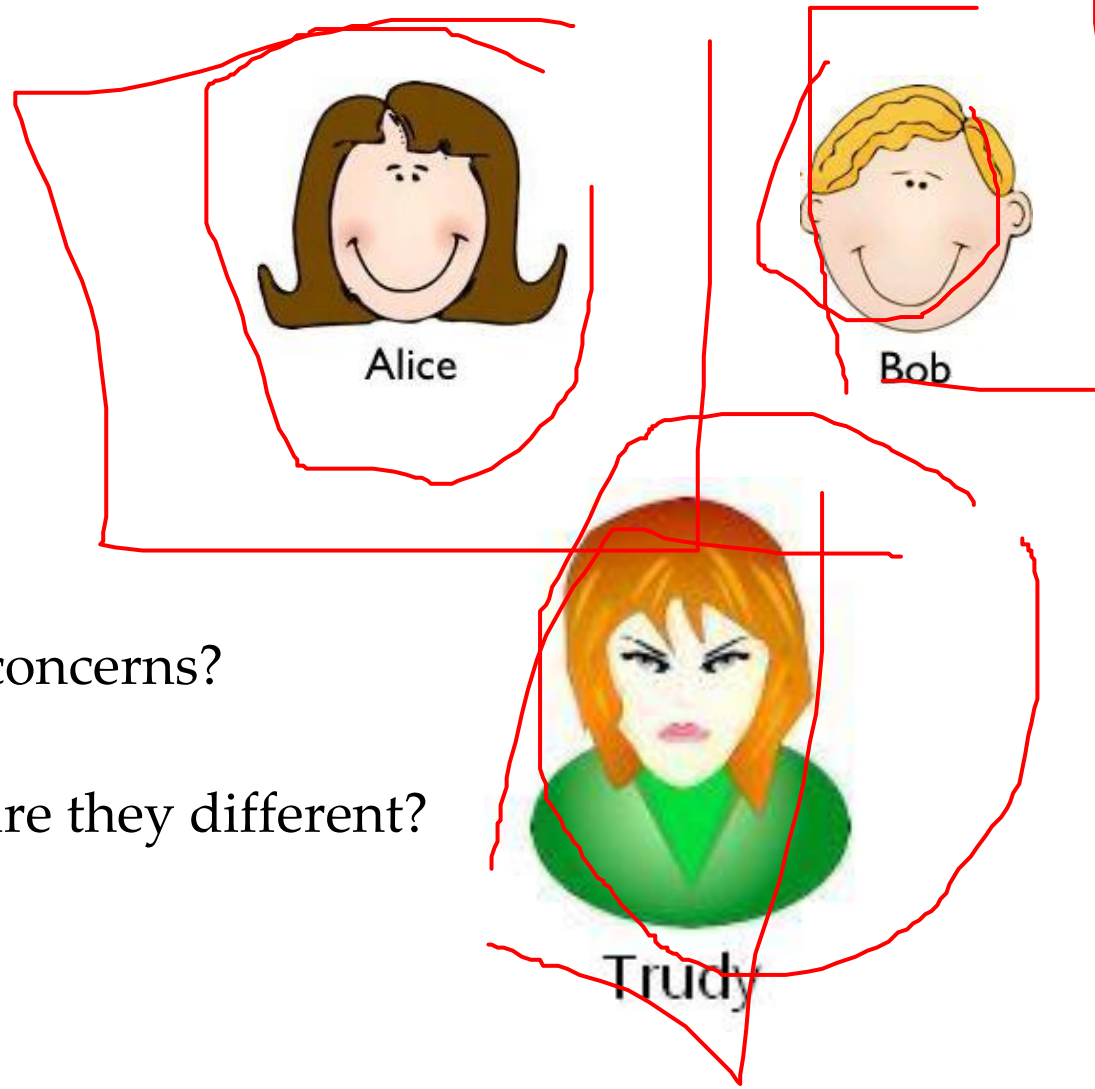
Definitions

- **Computer Security** - generic name for the collection of tools designed to protect data and to hinder hackers.
- **Network Security** - measures to protect data during their transmission.
- **Internet Security** - measures to protect data during their transmission over a collection of interconnected networks.

Basic Terminology

- **Plaintext –** original message.
- **Ciphertext** - coded message.
- **Cipher** - algorithm for transforming plaintext to ciphertext.
- **Encipher** (encrypt) - converting plaintext to ciphertext.
- **Decipher** (decrypt) - recovering ciphertext from plaintext.
- **Key** - information used in cipher known only to sender/receiver.
- **Cryptography** - study of encryption principles/methods.

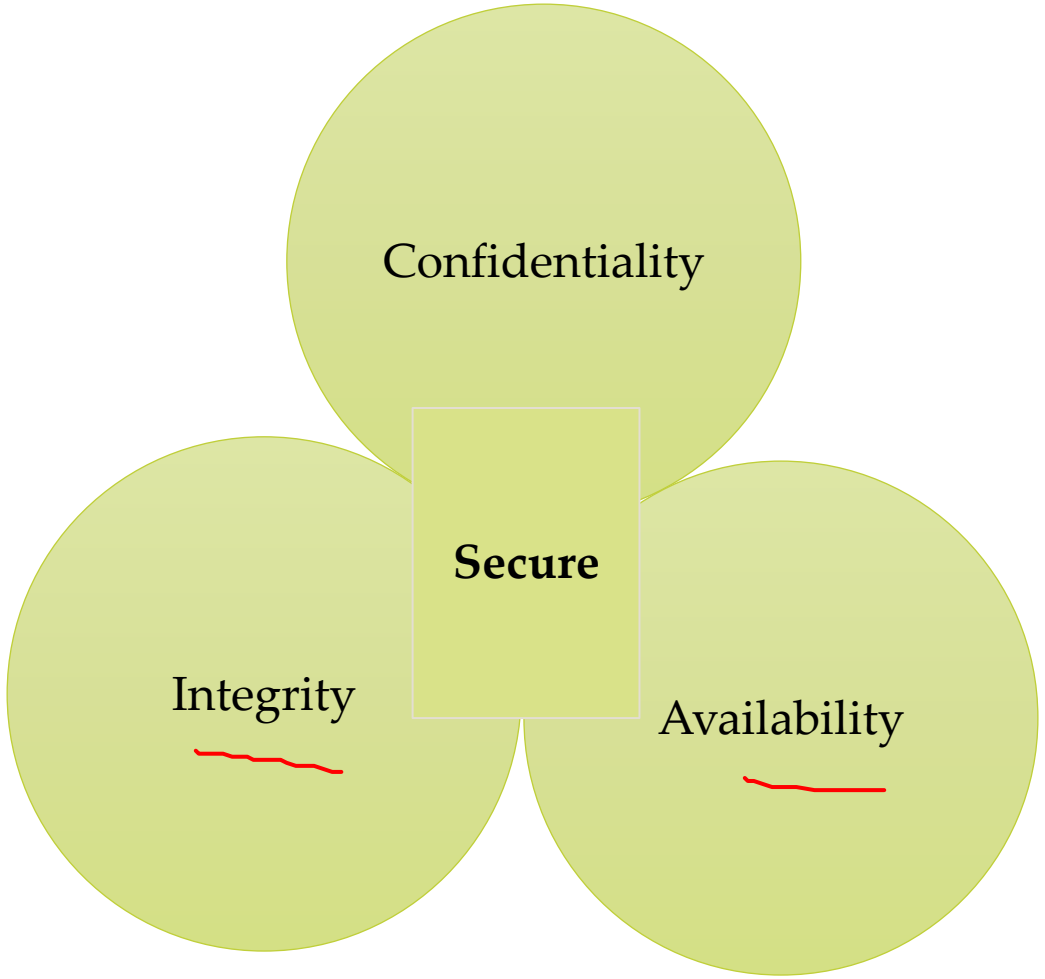
Alice's Online Bank



- Alice opens "Alice's Online Bank" (AOB)
- What are Alice's security concerns?
- If Bob is a customer of AOB, what are his security concerns?
- How are Alice's and Bob's concerns similar? How are they different?
- How does Trudy view the situation?

Security Goals

- There are three fundamental goals
- Confidentiality, Integrity, and Availability **CIA**



Confidentiality

- AOB must prevent Trudy from learning Bob's account balance
- **Confidentiality**: prevent unauthorized reading of information
- Cryptography used for confidentiality

Integrity


Alice


Bob

- Trudy must not be able to change Bob's account balance
- Bob must not be able to improperly change his own account balance
- Integrity: detect unauthorized writing of information
- Cryptography used for integrity


Trudy

Availability

- AOB's information must be available whenever it's needed.
- Alice must be able to make transaction.
  - If not, she'll take her business elsewhere.
- Availability: Data is available in a timely manner when needed.
- Availability is a "new" security concern.
  - Denial of service (DoS) attacks.

Beyond CIA: Crypto

- How does Bob's computer know that "Bob" is really Bob and not Trudy?
- Bob's password must be verified
  - This requires some clever cryptography
- What are security concerns of pwds?
- Are there alternatives to passwords?

Beyond CIA: Protocols

- When Bob logs into AOB, how does AOB know that "Bob" is really Bob?
- As before, Bob's password is verified
- Unlike the previous case, network security issues arise
- How do we secure network transactions?
  - Protocols are critically important
  - Crypto plays critical role in protocols

Beyond CIA: Access Control

- Once Bob is authenticated by AOB, then AOB must restrict actions of Bob.
  - Bob can't view Charlie's account info.
  - Bob can't install new software, etc.
  - Sam, AOB system administrator, can install new accounting software. (authorization)
- Access control includes both authentication and authorization.

Beyond CIA: Software

- Cryptography, protocols, and access control are implemented in software
  - Software is foundation on which security rests
- What are security issues of software?
  - Real world software is complex and buggy
  - Software flaws lead to security flaws
  - How does Trudy attack software?
  - How to reduce flaws in software development?
  - And what about malware?

The People Problem

- People often break security
  - Both intentionally and unintentionally
  - Here, we consider the unintentional
- For example, suppose you want to buy something online
  - To make it existing, suppose you want to buy "Information Security: Principles and Practice, 2nd edition from amazon.com"

The People Problem

- To buy from amazon.com
  - Your Web browser uses SSL protocol
  - SSL relies on cryptography
  - Access control issues arise
  - All security mechanisms are in software
- Suppose all of this security stuff works perfectly
  - Then you would be safe, right?

The People Problem

- What could go wrong?
- Trudy tries man-in-the-middle attack
  - SSL is secure, so attack doesn't "work"
  - But, Web browser issues a warning
  - What do you, the user, do?
- If user ignores warning, attack works!
  - None of the security mechanisms failed
  - But user unintentionally broke security

Cryptography

- “Secret codes”
- This topic covers
  - Classic cryptography
  - Symmetric ciphers
  - Public key cryptography
  - Hash functions++

Access Control

- Authentication
  - Passwords
  - Biometrics
  - Other methods of authentication
- Authorization
  - Access Control Lists/Capabilities
  - Firewalls, intrusion detection (IDS)
  - Multilevel security (MLS), security modelling, covert channel, inference control

Protocols

- "Simple" authentication protocols
  - Focus on basics of security protocols
  - Lots of applied cryptography in protocols
- Real-world security protocols
  - SSH, SSL, IPSec, Kerberos
  - Wireless: WEP, GSM

Software

- Security-critical flaws in software
  - Buffer overflow
  - Race conditions, etc.
- Malware
  - Viruses and worms
  - Prevention and detection

Software

- Software reverse engineering (SRE)
  - How hackers “dissect” software
- Software and testing
  - Open source, closed source, other topics
- Operating systems
  - Basic OS security issues
  - “Trusted OS” requirements

Think Like Trudy

- In the past, no respectable sources talked about “hacking” in detail
  - After all, such info might help Trudy
- Recently, this has changed
  - Lots of books on network hacking, evil software, how to hack software, etc.
  - Classes teach virus writing, SRE, etc.

Think Like Trudy

- Good guys must think like bad guys!
- A police detective…
  - …must study and understand criminals
- In information security
  - We want to understand Trudy's methods
  - Might think about Trudy's motives
  - We'll often pretend to be Trudy

… Thank you …