Week 1

Overview Lecture

Subject Overview

Lecture 1

Introduction to cr

Lecture 2

Introduction to Numbers

Workshops start from Week 2

Quiz 1

Intr raphy

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Lecture 1

Introduction to cryptography

Lecture 1

1.1 Information Security

- Definitions, Role of Cryptography, Cyber Security
- Story of Cryptography since ancient times
- A story of Alic

1.2 Motivating Exam

- Practical Banking
- A Communication Game:

1.3 Classical example

- Diffie-Hellman Protocol

1.4 Basic Security Objectives

Assignment Project Exam Help

1. rity

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Add WeChat edu_assist_pro

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Lecture 1

Information Security

Definitions, Role of Cryptography, Cyber Security

- What is Cryptography?
  - "Secret Writing"
  - Refers to the techniques required for protecting data between authorized parties on information communication technologies in the presence of potentially malicious elemen
  - Refers to a range Signature, Hash functions, assuring Privacy, ata in the digital world.
- What is Information Security?
  - A broad topic of exchange and process on on modern computers and networks.
  - Confidentiality, Integrity, and Availability.
- What is Cyber Security?
  - Refers to management of attacks and risks by adversarial and malicious elements on computers and networks that support modern businesses and economy involving business, government, and community.

Information Security

The field of Network and Internet security

- Stallings Take:

  - The field of network and Internet security consists of measures to deter, prevent, lations that involve the transmission of

- Our Approach:

  - Is to study certain basic cryptographic primitives such as symmetric and public key cryptography, hash functions, message authentication and signatures, and use them explore the field of network and Internet security protocols.

Story of Cryptography since ancient times

Alice

Let us meet in the alley today

Eve

Let us meet in the alley today

Bob

Images: General Internet resources

Story of Cryptography since ancient times

Alice

Let us meet in the alley today

Eve

Let us meet in the alley today

key

Bob

XYZ UKN SSJV GU

Let us meet in the alley today

key

E

C

C'

D

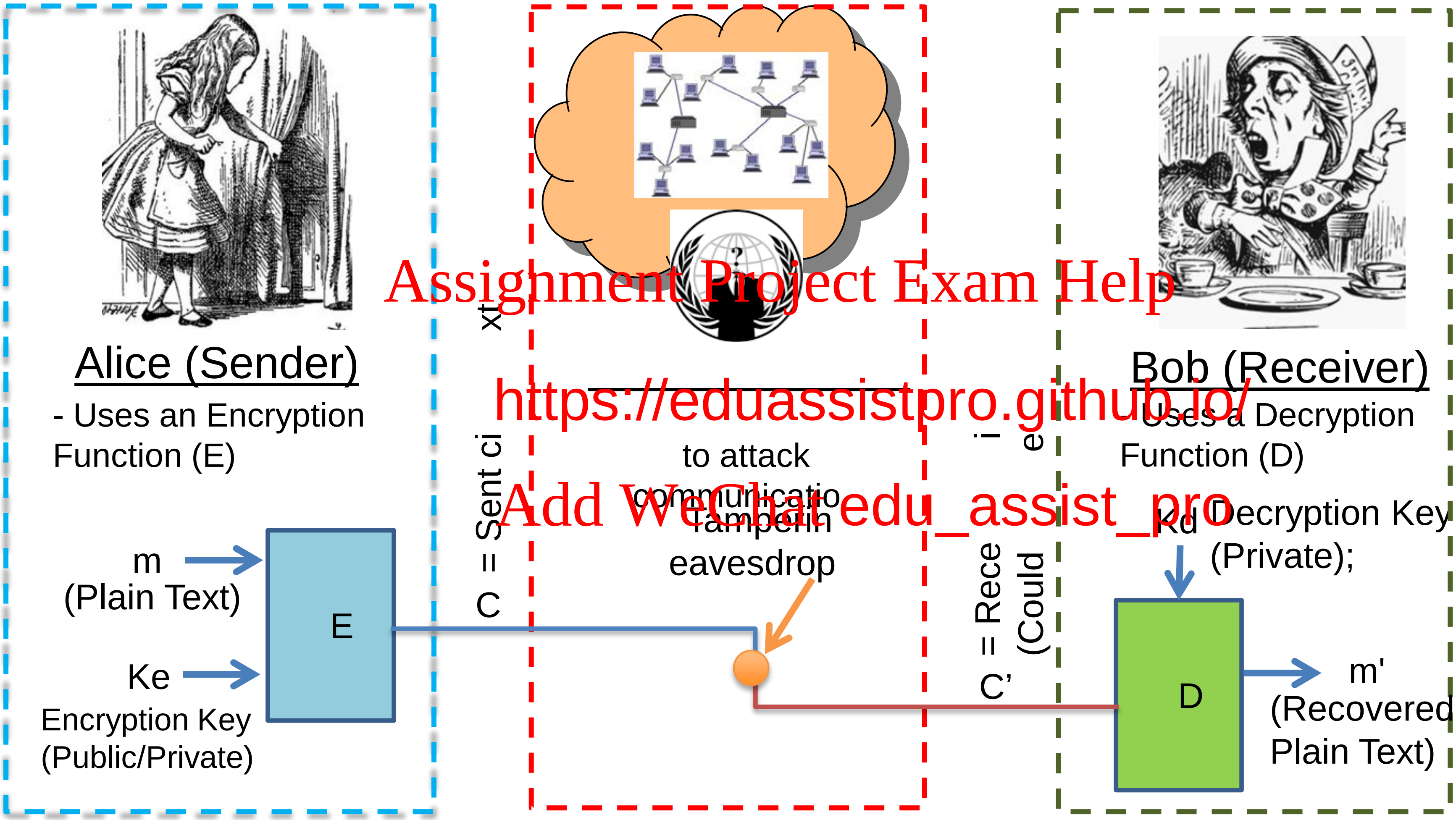
Let us meet in the alley today

How do they agree on the "key"? -Chicken and Egg Problem

Images: General Internet resources

Fast forward: In Modern times

Story of Alice and Bob terms and notations



E, D are public; c is the ciphertext, c’ is received ciphertext; ideally m=m’;

Cryptography involves many conceptual ideas, we look at the basic functions

Images: General Internet resources

Differences

- Ke = Kd :Symmetric key also sometimes referred as private key. But we shall call always symmetric key-
  - Known since antiquity.

- Ke $\neq$ Kd : Asymm y-

  - Fairly recent- since 1974 after the c r by Diffie-Hellman.

  - Please read this paper. I have added a link to this page in LMS.

1.2 Motivating Examples

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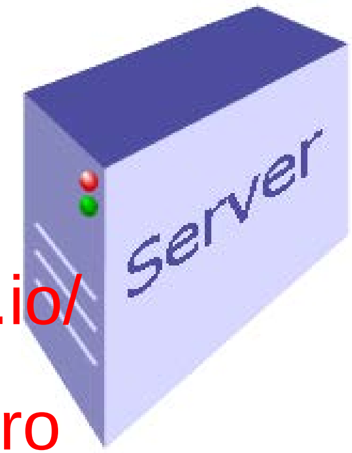
Lecture 1

Motivating examples

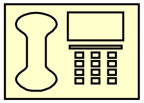
Comm bank Server



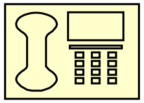
Issues in getting your money from the bank.
Should work over Internet
Think, who is Alice, Bob and Eve here.
What tools Cryptography can provide here?

A Communication Game

Alice



Dating Problem!



Bob

Alice and Bob wan

They want to decid rt or Cinema

They can resolve either way by tossin

If they can meet together, it is a simple task.

However, they are in different offices connected by a telephone.

They need to book the program in advance and want to make decision over the phone.

Can you help them?

A Cryptographic Solution Using Mathematics!

- Assume we have a magic function with

A. For every integer x, it is EASY to compute f(x) from x, however given a value for x which is the pre-image of f(x), eg en

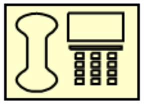
A. It is impossible to find a pair of in

x not equal to y and f(x) = f(y)

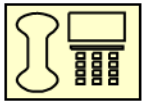
- Even number x in f(x) denotes EVEN and the other case denotes ODD.

A protocol

Alice



Dating Problem!



Bob

EVEN: HEADS
ODD: TAILS

Choose a random x and compute f(x)

es x is even or Odd

Send x

= f(x)
his guess
t or not

Whoever wins the game decides the venue of the meeting!

Is this protocol correct and fair (unbiased)?
Can you modify so that both Alice and Bob

If the line is not secure: Some questions

- They need to introduce traditional cryptography to secure the line
- Symmetric key or Asymmetric key?

- Or Use Different methods of communication where intruder cannot read the channel.
- We will discuss cry

Models for Information Security

- Traditional Communication Model:

  – Alice and Bob is connected by insecure channel. Marvin, an adversary can listen to their conversation and modify if needed.

- Modern Network

  – Network itself is an adversary. Mo rticipants. A valid participant also can be an adversary to others. Many models exist.

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One-Way functions

- Does One Way functions exist?

- This simple questi l issues. Cryptographers w xist and have come up with many practical one-way functi

- Do they have a clear cut proof for these claims?

- On the other hand, cryptanalysts believe in the opposite and work towards breaking the claims of cryptographers.

1.3 Classical example

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Lecture 1

Diffie-Hellman Idea: Basics

- Two users want to share a common secret over a public network, Is this possible? Think!
- For a moment assume that we have a one way function.
- What is one way fu
  - Given x in domain it is easy to co
  - Given y in range, it is difficult find x in domain such that f(x)=y

DH Continued

- Alice can create x in a domain (agreed in advance) –keep it secret,
- Compute f(x)– Send it to Bob over public channel

- Bob can create se lso computes f(y) – Send it back to Al

- Now both of them have f(x) and f(

- If f is such that they can workout a common function of their secrets which others who observed f(x) and f(y) cannot compute, then one can attempt to have a solution to this problem.
- Diffie-Hellman in their 1974 paper give one such concrete solution! Please read it, you will love the idea.

Prime Numbers

- A number is said to be a prime number if p > 1 and p has no positive divisors except 1 and p.
- Example: $p = 2,3,5,7,11,13$
- The numbers which are not prime numbers are referred as composite numbers.
- For any integer n, $n > 1$, let $Z_n = \{0, 1, 2, \ldots, n\text{-}1\}$ be a set of numbers. This set is called the set of resid emainders of integers divided by the numbe
- We define the followi e n.

- Example: $(6 + 7) \bmod 12 = 1$; $5 \times 4 \bmod 12 = 8$;
- In this lecture, n will only be a prime number.

Modular Inverse

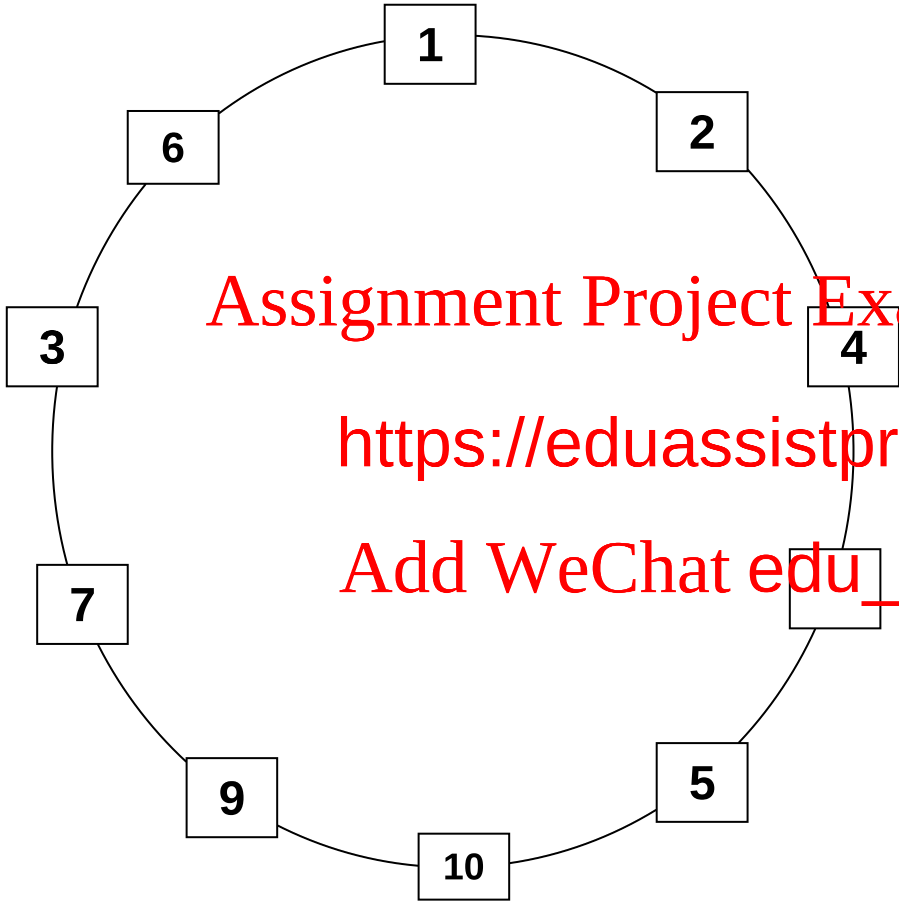
We can now define a cyclic group over nonzero elements of Z_p when p is prime.

Let $Z^*_p = \{1, 2, 3, \ldots, (p\text{-}1)\}$. Let g be an element of Z^*_p such that

$Z^*_p = \{g, g^2, g^3, \ldots, g^{p-1}=1\}$, (*you can always find such an element g)

*We do not cover this idea here, it requires more study; those interested can see the textbook

An example



g^i	$g^i \bmod p$	$Dlog(g^i)$
2^1	2	1
2^2	4	2
2^3	8	3
^{4}	5	4
[illegible]	10	5
2^6	9	6
2^7	7	7
2^8	3	8
2^9	6	9
2^{10}	1	10

Example of a Cyclic group modulo $p = 11$

g : generator = 2

Order(size) of G = 10

What power of 2 is 3?

The Example of One Way Function

X	2^x mod 11
0	1
1	2
2	4
3	
4	
5	10 Or -1
6	9
7	7
8	3
9	6
10	1
11	2

Discrete Logarithm Problem (DLP)

Let ‘*g*’ and ‘*h*’ be elements of the group G. Then the discrete logarithm (DL) problem is the problem of finding ‘*x* ’ such that $g^x = h$.

For example, the solution to *x* in the problem:

$3^x = 13 \pmod{17}$ -> *17).*

- The discrete log problem is believed to be t has become the basis of several public key schemes, for example

- Next, we will consider the Diffie-Hellman protocol, the first public key algorithm.

- The protocol is defined over a cyclic group: $Z^*_p = \{g, g^2, g^3, \ldots, g^{p-1}=1\}$,

Diffie-Hellman Key Establishment Protocol

- Alice — Bob
- Choose Na=2 — Choose Nb=6
- $g^{Na} = 2^2 = 4 = Ma$

- $= 9 = Mb$

- Compute
- $K_{ab} = Mb^{Na}$
- $= 9^2 = 4$
- Compute
- $K_{ba} = Ma^{Nb} = 4^6 = 4$
- $K_{ab} = K_{ba} = 4$

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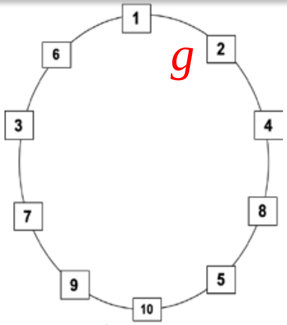
Diffie-Hellman Protocol



All arithmetic under *mod* $p=11$

Alice $p=11, g=2$ **Bob**

Choose Na=2 Eve

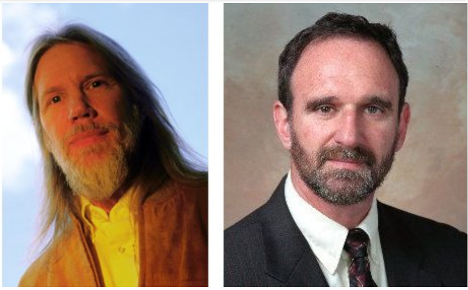
Choose Nb=6

$g^{Na} = 2^2 = 4 = Ma$ $g^{Nb} = 2^6 = 9 = Mb$

Compute Compute

$K_{ab} = Mb^{Na} = (g^{Nb})^{Na} = 9^2 = 4$ $K \;\; = Ma^{Nb} = (g^{Na})^{Nb} = 4$

$K_{ab} = K_{ba} = 4$



Whitfield Diffie and Martin Hellman

CDH PROBLEM — Problem for Eve in the above protocol

Clearly a solution to DL implies a solution to CDH

Is the converse True?*

* Open Problem

Let G be a cyclic group of size q and g be a generator of the group G. Given g^a and g^b, two arbitrary elements of the group G for some integers a and b in the range: $0 \leq a, b \leq q$, then find g^{ab}

Normally G is a multiplicative group in a suitable finite field.

New directions in Cryptography, IEEE Trans. Inf. Theory 22(6): 644-654 (1976)

Image from Wikimedia Commons

Issues wit this Protocol: Secure?

- Exchanged data -only g^{Na} and g^{Nb}
- So Alice cannot guess N_b nor Bob can guess N_a
- So their secrets are safe from each other
- But also none can guess Na and Nb for the same reason
- Both Alice and secret g^{NaNb}
- It is also believed that g^{NaNb} cann ted by others who can only see g^{Na} and g^{Nb}
- The later problem is known as Computational Diffie-Hellman problem (Hard!)

Man in the Middle Attack

- Alice Eve Bob
- g^{Na} g^{Nm} g^{Nb}
  - g^{NaNm} NmNb

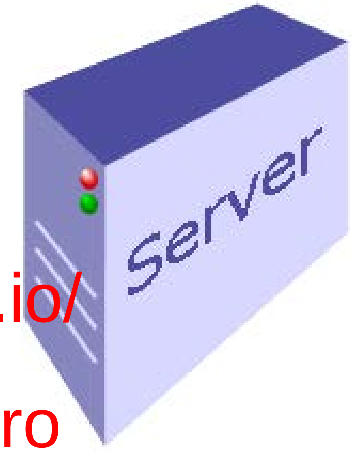
- Marvin comes in be … an create two secrets one with Alice and the other with Bob.

- This is possible because when Bob rec … ication from Alice, there is no way for him to determine if it indeed come from Alice, in other words, the messages are not authenticated.

- A way to solve this problem is by using digital signatures! –We will revisit these ideas when we visit Public Key topics later in the semester.

In Practice

Comm bank Server



1.4 Basic Security Objectives

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Lecture 1

Three important concerns of Information security

- Confidentiality
  - In simple terms, confidentiality of information or data ensures that the access is given only to authorized individuals.

- Integrity

  - Information int guarding mechanisms exists so that authorized individual information and any changes to the information by inte intentional means will be detected.

- Availability
  - Information or data availability ensures that the information is authorized available to the users.

From the textbook definitions

OSI Security Architecture

- How to define the requirements for security in networked world and characterizing the approaches to satisfy those requirements?

- Refer to ITU-T X.800 "Security Architecture for OSI"
  - It defines a systema ity requirements

- Three main aspects:
  - Security attacks
  - Security Mechanisms.
  - Security services.

Security Attack

- *Attack* is any action that compromises the security of information owned by an organization
- *Threat* is a possible potential for violation of security,

- Information sec nt attacks, or failing that, to detect att
- often *threat* & *attack* used to me g (threat is attack in waiting)
- Generally we have a wide range of attacks:
- Some generic types of attacks:
  - passive
  - active

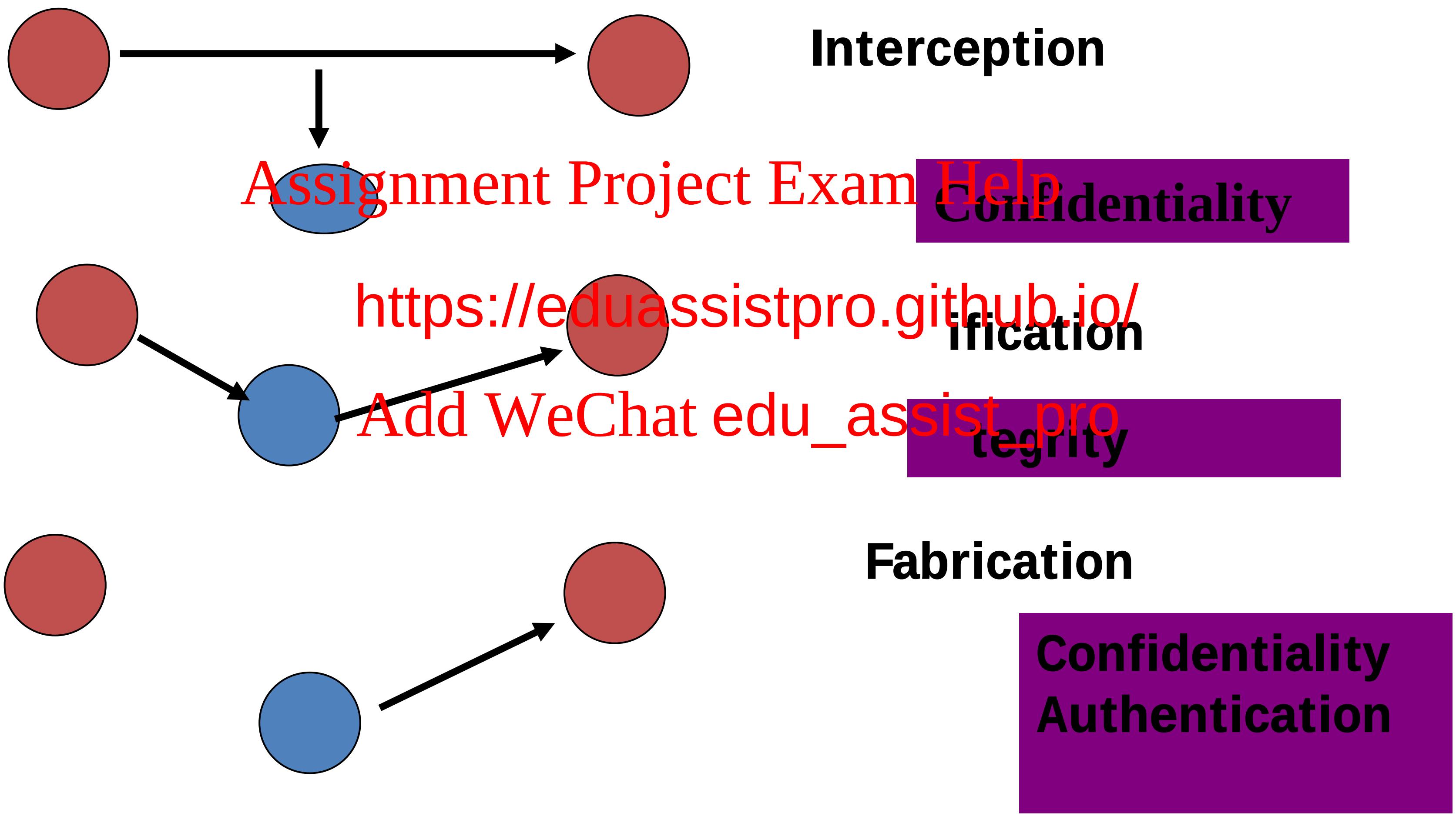
Basics Security Services

We concentrate on Implementation and Mechanism aspects of Information Security.

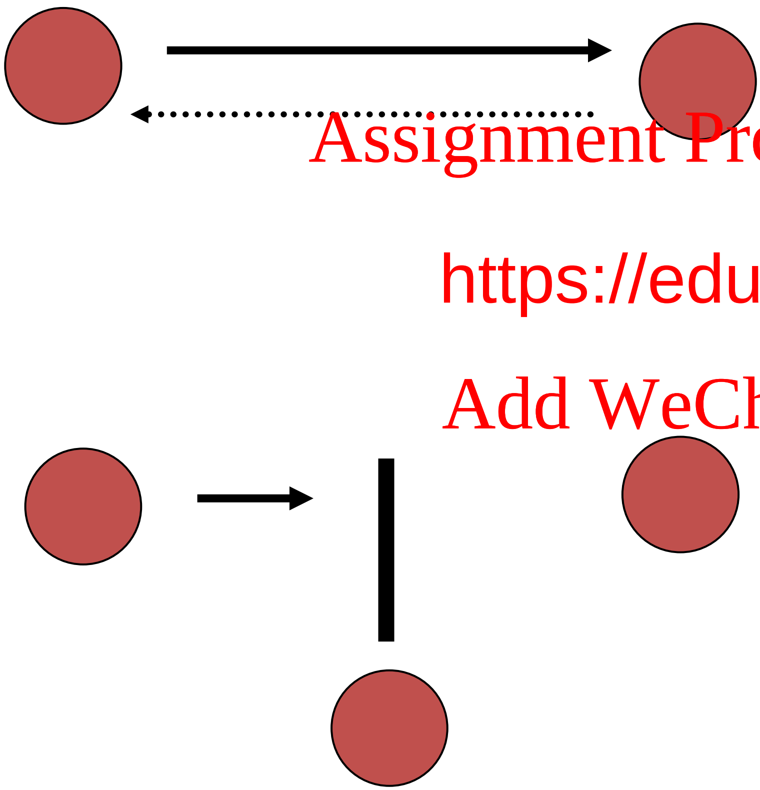
- Authentication
- Confidentiality
- Integrity
- Nonrepudiation
- Availability

Security Threats in Networked World

- Security services are defined to address or withstand threats



Security Threats in Networked World



Non-Repudiation

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Interruption

Network QOS

Model for Network Security (Textbook)

Source: WilliamStallings, Cryptograph and Security

Network Access Security Model

Source: WilliamStallings, Cryptograph and Security

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Introduction to crypt

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Introduction to Numbers

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