Network Security - Project

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Introduction

- Select **one** of two projects, and complete it by **yourself**
- Due date: Friday of 18th week
- Deliverable:
  - Project{1/2}_${Student_id}_${your_name}.{tar.gz/rar/zip}
    - Task 1
      - Your code/data for task 1
    - Task 2
      - Your code/data for task 2
    - Task 3
      - Your code/data for task 3
    - Project{1/2}_report_${Student_id}_${your_name}.pdf

Contents

Project 1 – Task 1

- Goal: Implement the textbook RSA algorithm(without any padding)
- Your code should be able to:
  - **Generate** a random RSA key pair with a given key size (e.g., 1024bit)
  - **Encrypt** a plaintext with the public key.
  - **Decrypt** a ciphertext with the private key.

Project 1 - Task 2

- Goal : Perform a CCA2 attack on textbook RSA
- Textbook RSA is elegant, but has **no semantic security**.
- An adaptive chosen-ciphertext attack (abbreviated as CCA2) is an interactive form of chosen-ciphertext attack in which an attacker sends a number of ciphertexts to be decrypted, then uses the results of these decryptions to select subsequent ciphertexts.
- The goal of this attack is **to gradually reveal** information about an encrypted message, or about the decryption key itself.

Project 1 - Task 2

- Refer an existing work for the implementation
  - Details of this attack can be found in **Chap 4**.
- Since QQ browser has fixed the problem, you are supposed to simulate the attack

When Textbook RSA is Used to Protect the Privacy of Hundreds of Millions of Users

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- *Knockel J, Ristenpart T, Crandall J. When textbook RSA is used to protect the privacy of hundreds of millions of users[J]. arXiv preprint arXiv:1802.03367, 2018.*

Project 1 - Task 2

Server-client communication

Client

① generate a 128-bit AES session key for the session.

② encrypt this session key using a 1024-bit RSA public key.

③ use the AES session key to encrypt the WUP request.

④ send the RSA-encrypted AES session key and the encrypted WUP request to the server.

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① decrypt the RSA-encrypted AES key it received from the client.

② choose the least significant 128 bits of the plaintext to be the AES session key.

③ decrypt the WUP request using the AES session key.

④ send an AES-encrypted response if the WUP request is valid.

Server

Project 1 - Task 2

- In this attack, the server knows
  - RSA key pair, AES key
- The adversary knows
  - RSA public key, a RSA-encrypted AES key, an AES-encrypted WUP request
- The adversary wants to know
  - AES key

Project 1 - Task 2

- In this part, you are supposed to
  - Properly design your own **WUP** request format, server-client communication model, etc. A nice design will bring you a bonus.
  - **Generate** a history message by yourself, it should includes a RSA-encrypted AES key and an AES-encrypted request.
  - Present the **attack** process to obtain the AES key (and further decrypt the encrypted request) from the history message.
- You can use third-party library to implement **AES** encryption and decryption.

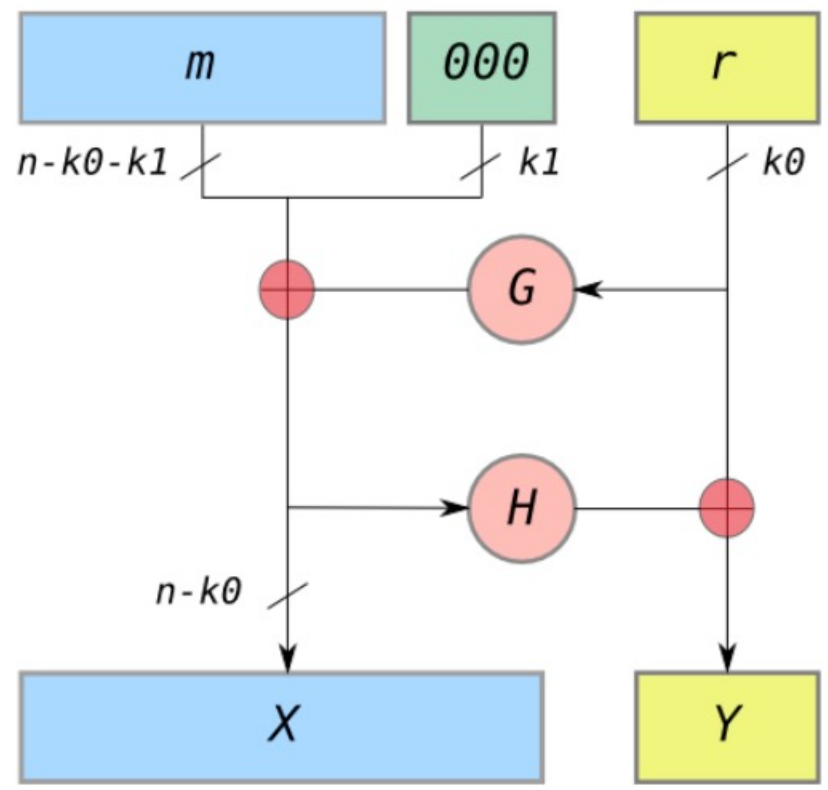
- About WUP: *https://citizenlab.ca/2016/03/privacy-security-issues-qq-browser/*

Project 1 - Task 3

- Goal: defend the attack
  - **Implement RSA-OAEP algorithm and discuss why it can defend such kind of attacks.**
- Since textbook RSA is vulnerable to attacks, in this paper, the authors give a solution: **using OAEP key padding algorithm**.
- In cryptography, Optimal Asymmetric Encryption Padding (**OAEP**) is a padding scheme often used together with RSA encryption. OAEP satisfies the following two goals:
  - Add an element of randomness which can be used to convert a **deterministic** encryption scheme (e.g., traditional RSA) into a **probabilistic** scheme.
  - **Prevent partial decryption** of ciphertexts (or other information leakage) by ensuring that an adversary cannot recover any portion of the plaintext without being able to invert the trapdoor one-way permutation.

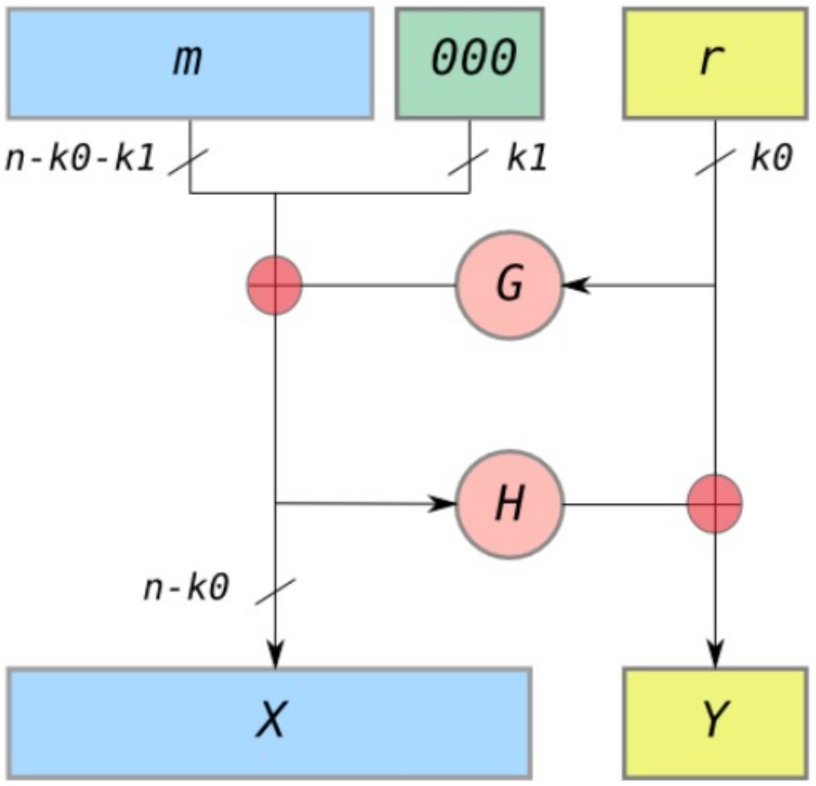
Project 1 - Task 3: OAEP

- n is the number of bits in the RSA modulus.
- $k0$ and $k1$ are integers fixed by the protocol.
- m is the plaintext message, an $(n-k0-k1)$ bit string
- G and H are typically some cryptographic hash functions fixed by the protocol.
- $\oplus$ is an xor operation



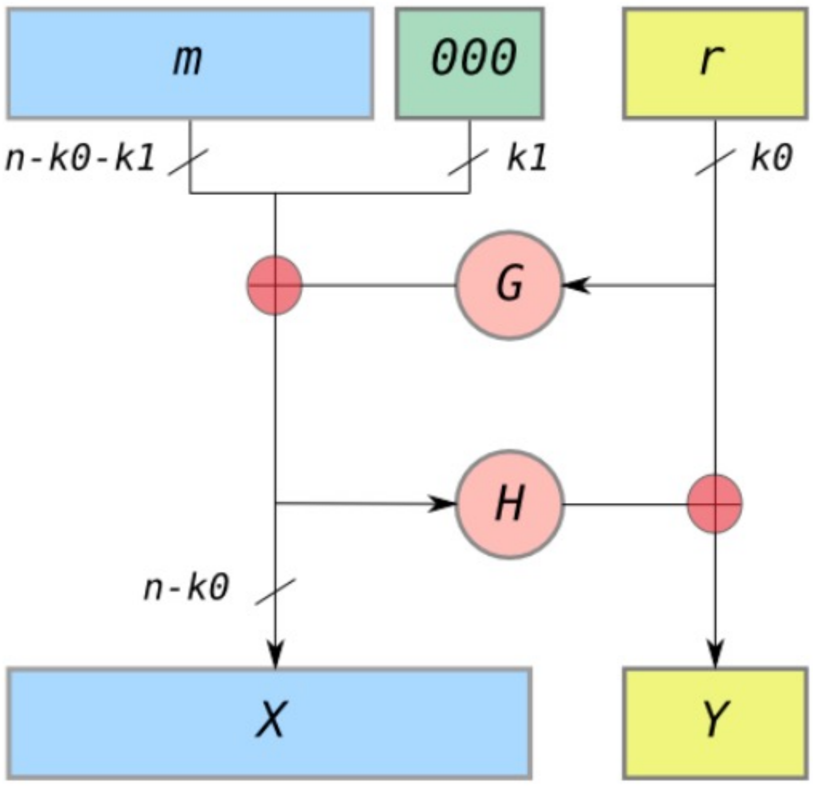
Project 1 - Task 3: OAEP encoding

1. *messages are padded with k1 zeros to be n−k0 bits in length.*
2. *r is a randomly generated k0 bit string*
3. *G expands the k0 bits of r to n−k0 bits.*
4. $X = m00..0 \oplus G(r)$
5. *H reduces the n−k0 bits of X to k0 bits.*
6. $Y = r \oplus H(X)$
7. *The output is X || Y where X is shown in the diagram as the leftmost block and Y as the rightmost block*



Project 1 - Task 3: OAEP decoding

1. *recover the random string as* $r = Y \oplus H(X)$
2. *recover the message as* $m00..0 = X \oplus G(r)$
3. *The "all-or-nothing" security is from the fact that to recover m, you must recover the entire X and the entire Y; X is required to recover r from Y, and r is required to recover m from X. Since any changed bit of a cryptographic hash completely changes the result, the entire X, and the entire Y must both be completely recovered.*



Project 1 - Task 3

- In this part, you are supposed to
  - Add the **OAEP padding** module to the textbook RSA implementation.
  - Give a **discussion** on the advantages of RSA-OAEP compared to the textbook RSA.
  - As a bonus, you can further try to **present** CCA2 attack to **RSA-OAEP** to see whether it can thwart the CCA2 attack you have implemented in part 2.

Thank You