Final Year B.Tech. (CSE) – VII [2024-25]

6CS451: Cryptography and Network Security Lab (C&NS Lab)

Date: 26/08/2024

Assignment 7

PRN: 21510042 **Name:** Omkar Rajesh Auti

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1. Implementation of RSA Algorithm

Ans:

The RSA algorithm is one of the first public-key cryptosystems and is widely used for secure data transmission. It is an asymmetric cryptographic algorithm, meaning it uses a pair of keys: a public key for encryption and a private key for decryption. It relies on the mathematical properties of prime numbers.

How RSA Works:

1. **Key Generation:**
   - Choose two large prime numbers p and q.
   - Compute n = p * q.
   - Compute the totient $\phi(n) = (p-1) * (q-1)$.
   - Choose an encryption key e such that $1 < e < \phi(n)$ and $\gcd(e, \phi(n)) = 1$. The integer e is the public key exponent.
   - Calculate the decryption key d such that $d * e \equiv 1 \pmod{\phi(n)}$. The integer d is the private key exponent.
2. **Encryption:**
   - The public key is (n, e).
   - Given a plaintext message M, the ciphertext C is computed as:

     C = M^ e mod n.
3. **Decryption:**

- The private key is (n, d).
- Given a ciphertext C, the plaintext M is recovered as:

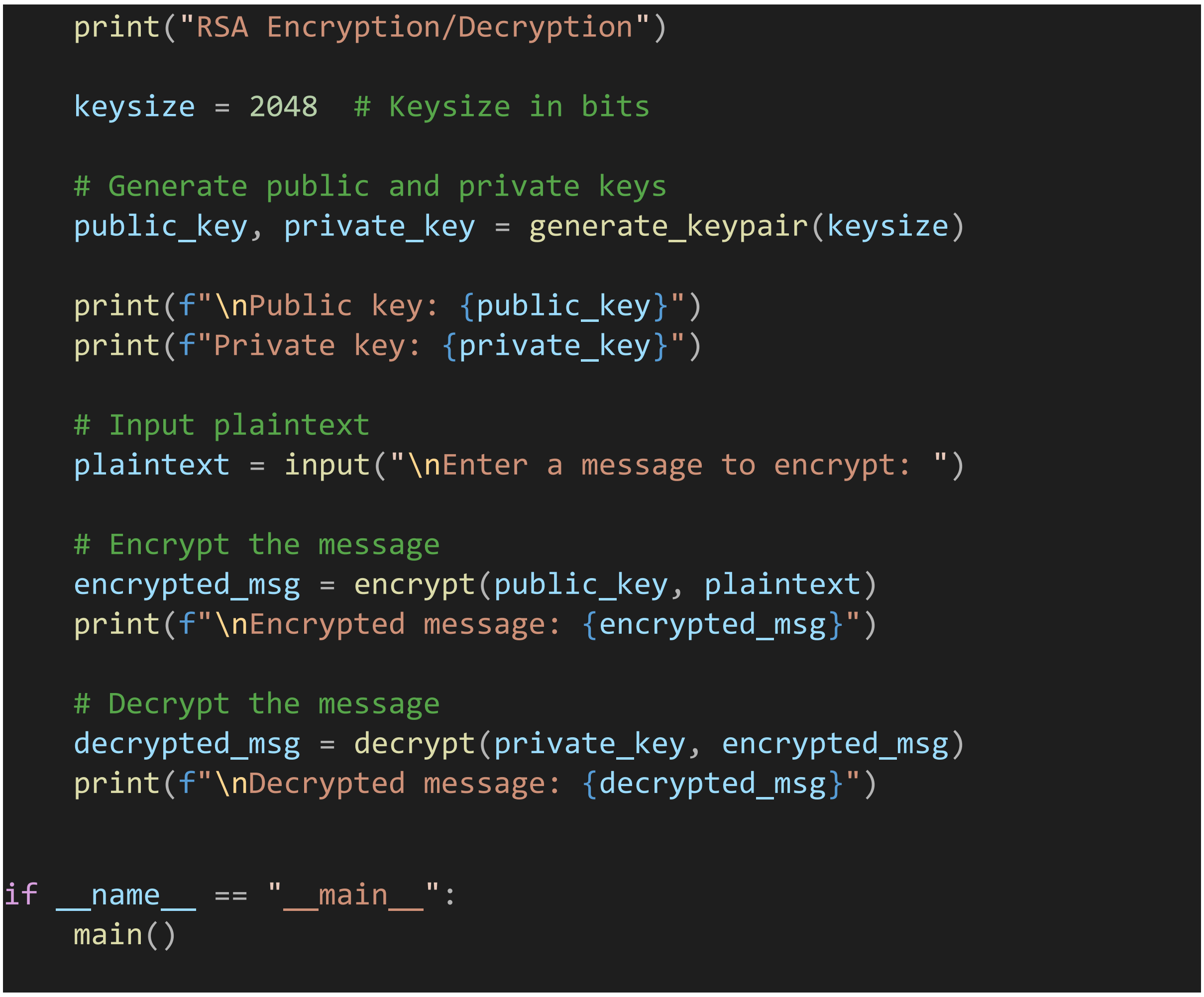
  M = C^d mod n

To implement the RSA algorithm **using large prime numbers with 2048 bits** and converting plaintext into numbers, we'll use the **Crypto library in Python**, which provides the **necessary tools to handle such large prime numbers and perform RSA encryption and decryption.**

The large primes and the strong key sizes make RSA secure against most attacks when implemented correctly.

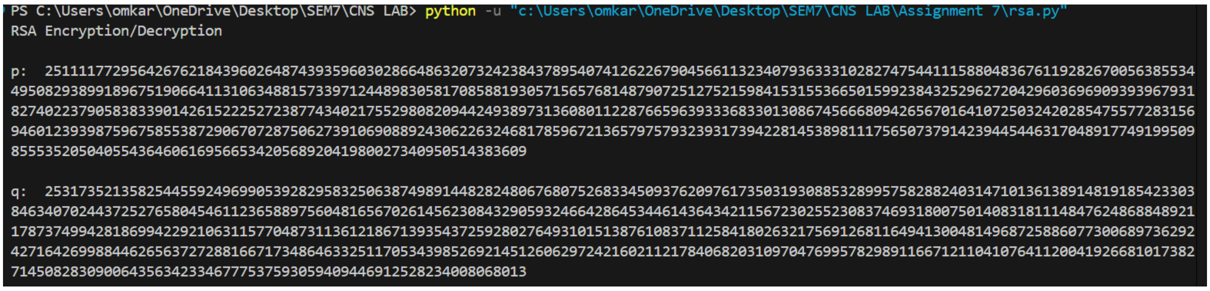
Python Code:

```python
import random
from sympy import isprime, mod_inverse

def generate_prime_candidate(length):
    """Generate an odd integer randomly."""
    p = random.getrandbits(length)
    # Ensure p is odd
    p |= (1 << length - 1) | 1
    return p


def generate_prime_number(length):
    """Generate a prime number."""
    p = 4
    while not isprime(p):
        p = generate_prime_candidate(length)
    return p


def generate_keypair(keysize):
    """Generate RSA public and private keys."""
    # Generate two large primes p and q
    p = generate_prime_number(keysize)
    q = generate_prime_number(keysize)

    print("\np: ", p)
    print("\nq: ", q)

    # Compute n = p * q
    n = p * q

    # Compute Euler's Totient ϕ(n) = (p-1)*(q-1)
    phi = (p - 1) * (q - 1)

    # Choose an integer e such that 1 < e < phi(n) and gcd(e, phi(n)) = 1
    e = random.randrange(2, phi)
    g = gcd(e, phi)
    while g != 1:
        e = random.randrange(2, phi)
        g = gcd(e, phi)

    # Compute d, the modular inverse of e
    d = mod_inverse(e, phi)

    # Public key (e, n) and Private key (d, n)
    return ((e, n), (d, n))


def gcd(a, b):
    """Compute the greatest common divisor using Euclid's algorithm."""
    while b != 0:
        a, b = b, a % b
    return a


def encrypt(public_key, plaintext):
    """Encrypt plaintext using the public key."""
    e, n = public_key
    cipher = [pow(ord(char), e, n) for char in plaintext]
    return cipher


def decrypt(private_key, ciphertext):
    """Decrypt ciphertext using the private key."""
    d, n = private_key
    plain = [chr(pow(char, d, n)) for char in ciphertext]
    return ''.join(plain)


def main():
    """Run RSA algorithm."""
```



```
    print("RSA Encryption/Decryption")

    keysize = 2048  # Keysize in bits

    # Generate public and private keys
    public_key, private_key = generate_keypair(keysize)

    print(f"\nPublic key: {public_key}")
    print(f"Private key: {private_key}")

    # Input plaintext
    plaintext = input("\nEnter a message to encrypt: ")

    # Encrypt the message
    encrypted_msg = encrypt(public_key, plaintext)
    print(f"\nEncrypted message: {encrypted_msg}")

    # Decrypt the message
    decrypted_msg = decrypt(private_key, encrypted_msg)
    print(f"\nDecrypted message: {decrypted_msg}")


if __name__ == "__main__":
    main()
```

Output:



```
PS C:\Users\omkar\OneDrive\Desktop\SEM7\CNS LAB> python -u "c:\Users\omkar\OneDrive\Desktop\SEM7\CNS LAB\Assignment 7\rsa.py"
RSA Encryption/Decryption

p:  25111177295642676218439602648743935960302866486320732423843789540741262226790456611323407936333102827475441115880483676119282670056385534
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q:  25317352135825445592496990539282958325063874989144828248067680752683345093762097617350319308853289957582882403147101361389148191854233O3
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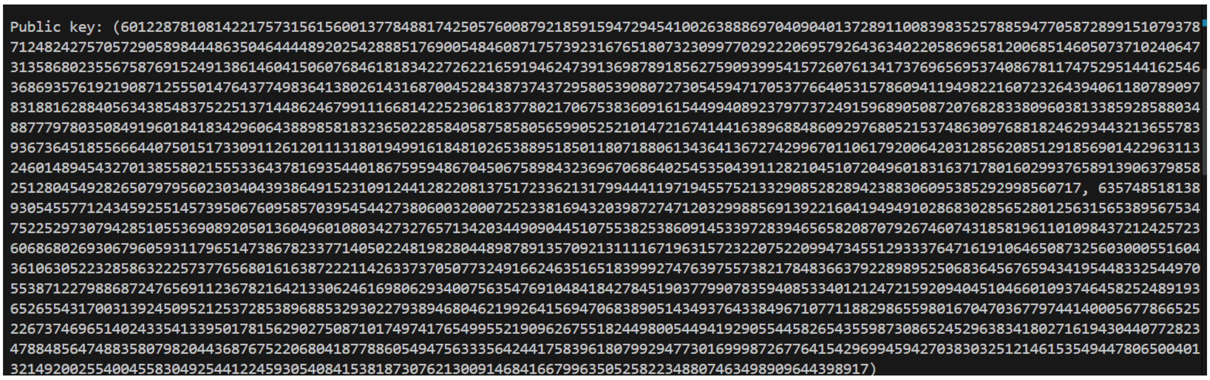

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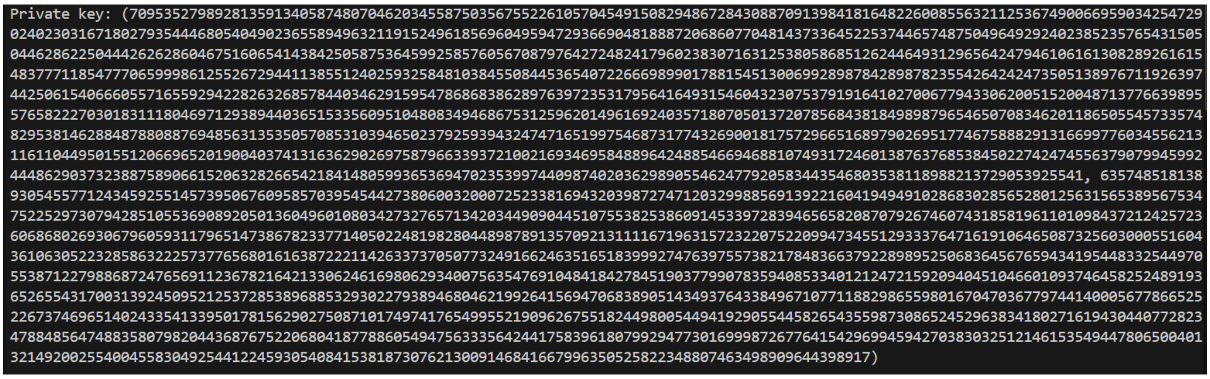

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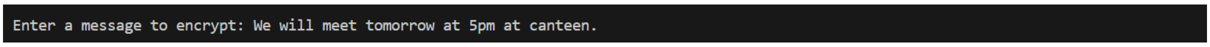

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Enter a message to encrypt: We will meet tomorrow at 5pm at canteen.
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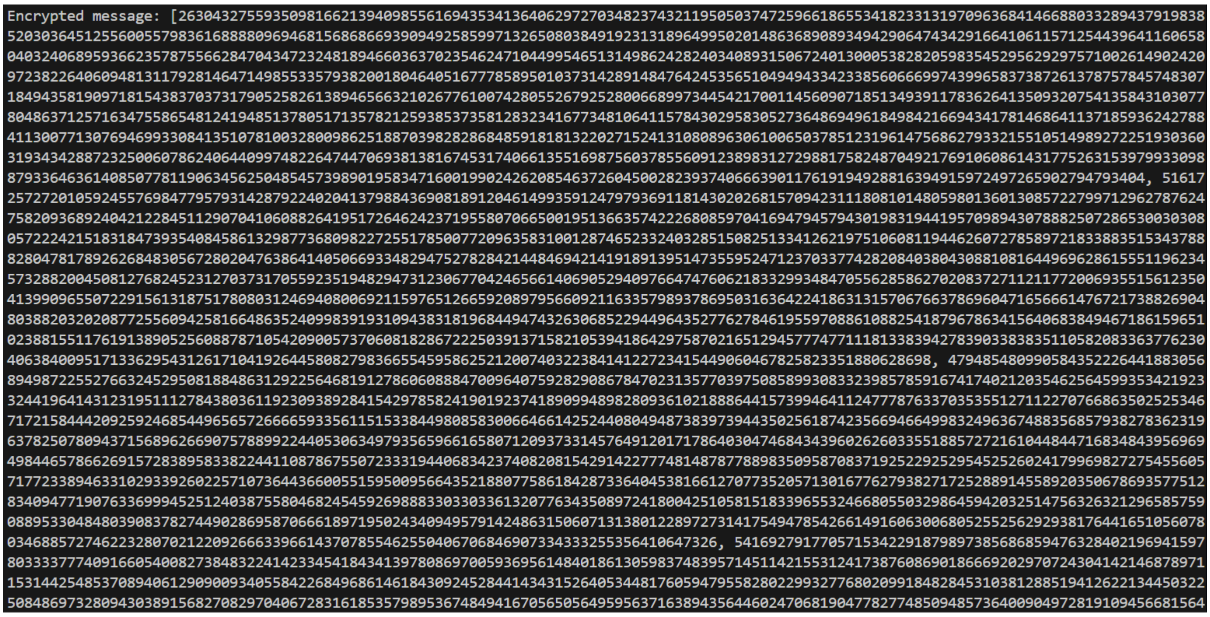

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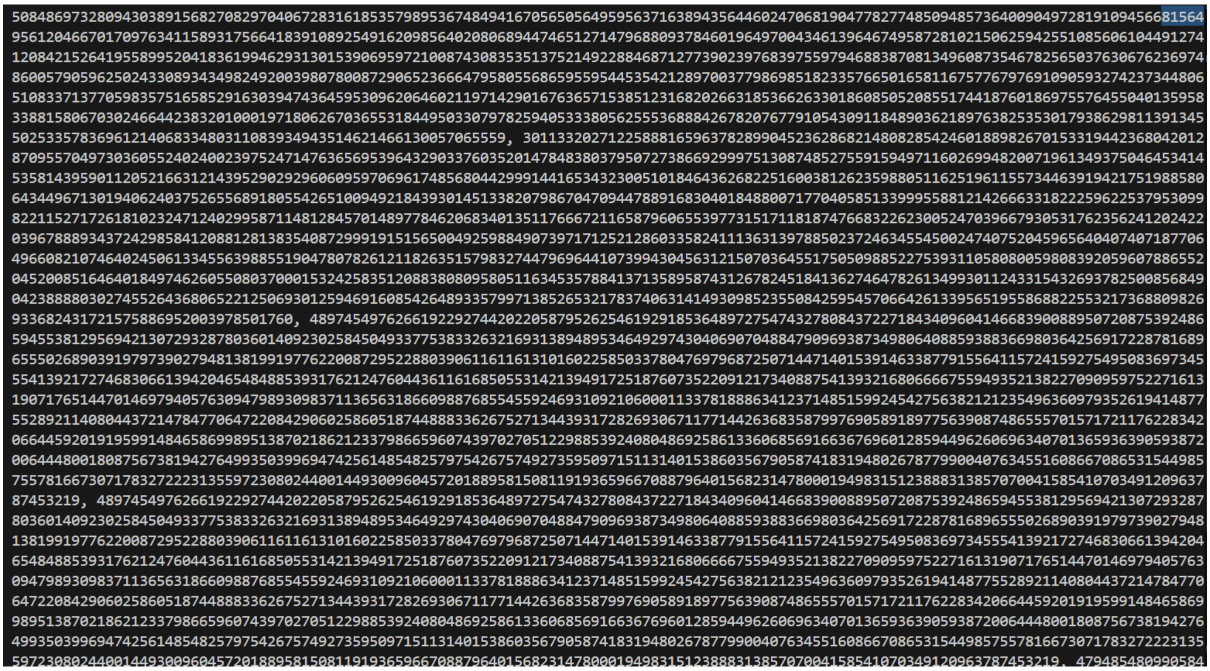

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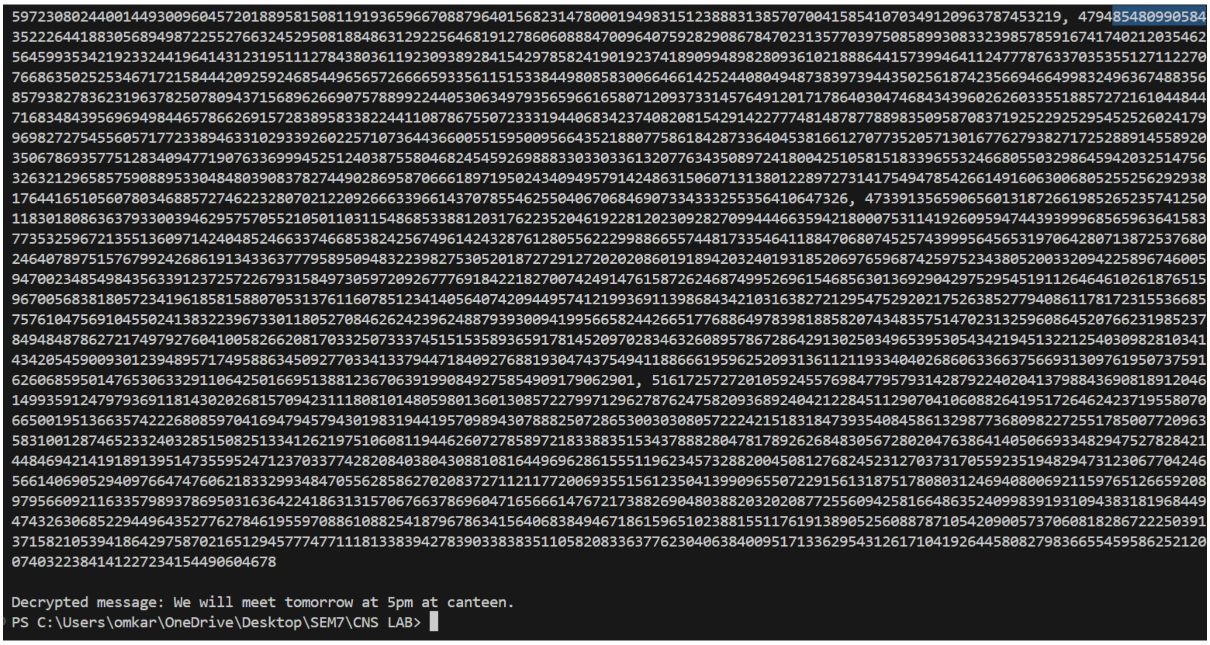

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Decrypted message: We will meet tomorrow at 5pm at canteen.
PS C:\Users\omkar\OneDrive\Desktop\SEM7\CNS LAB> 
```

Practical Applications of RSA

- **Secure Communication**: Encrypting emails and messages.
- **Digital Signatures:** Verifying the authenticity of a message or document.
- **Key Exchange**: Securely exchanging keys for symmetric encryption algorithms.

RSA is widely used in various security protocols, including SSL/TLS for secure internet communications.

RSA ensures security through the difficulty of factoring large numbers. It is commonly used for securing sensitive data, digital signatures, and in SSL/TLS protocols.