

Міністерство освіти і науки України Національний технічний університет України "Київський політехнічний інститут імені Ігоря Сікорського" Фізико-технічний інститут

Криптографія

Лабораторна №4

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Мета та основні завдання роботи

Ознайомлення з тестами перевірки чисел на простоту і методами генерації ключів для асиметричної криптосистеми типу RSA; практичне ознайомлення з системою захисту інформації на основі криптосхеми RSA, організація з використанням цієї системи засекреченого зв'язку й електронного підпису, вивчення протоколу розсилання ключів.

Порядок виконання роботи

- 1. Написати функцію пошуку випадкового простого числа з заданого інтервалу або заданої довжини, використовуючи датчик випадкових чисел та тести перевірки на простоту. В якості датчика випадкових чисел використовуйте вбудований генератор псевдовипадкових чисел вашої мови програмування. В якості тесту перевірки на простоту рекомендовано використовувати тест Міллера-Рабіна із попередніми пробними діленнями. Тести необхідно реалізовувати власноруч, використання готових реалізацій тестів не дозволяється.
- 2. За допомогою цієї функції згенерувати дві пари простих чисел p, q і p_1 , q_1 довжини щонайменше 256 біт. При цьому пари чисел беруться так, щоб pq $\leq p_1q_1$; p і q прості числа для побудови ключів абонента A, p_1 і q_1 абонента B.
- 3. Написати функцію генерації ключових пар для RSA. Після генерування функція повинна повертати та/або зберігати секретний ключ (d, p, q) та відкритий ключ (n, e). За допомогою цієї функції побудувати схеми RSA для абонентів A і B тобто, створити та зберегти для подальшого використання відкриті ключі (e, n), (e, n) та секретні d і d1
- 4. Написати програму шифрування, розшифрування і створення повідомлення з цифровим підписом для абонентів A і В. Кожна з операцій (шифрування, розшифрування, створення цифрового підпису, перевірка цифрового підпису) повинна бути реалізована окремою процедурою, на вхід до якої повинні подаватись лише ті ключові дані, які необхідні для її виконання.

За допомогою датчика випадкових чисел вибрати відкрите повідомлення M і знайти криптограму для абонентів A и B, перевірити правильність розшифрування. Скласти для A і B повідомлення з цифровим підписом і перевірити його.

5. За допомогою раніше написаних на попередніх етапах програм організувати роботу протоколу конфіденційного розсилання ключів з підтвердженням справжності по відкритому каналу за допомогою алгоритму RSA. Протоколи роботи кожного учасника (відправника та приймаючого) повинні бути реалізовані у вигляді окремих процедур, на вхід до яких повинні подаватись лише ті ключові дані, які необхідні для виконання. Перевірити роботу програм для випадково обраного ключа 0 < k < n.

Кожна з наведених операцій повинна бути реалізована у вигляді окремої процедури, інтерфейс якої повинен приймати лише ті дані, які необхідні для її роботи; наприклад, функція Encrypt(), яка шифрує повідомлення для абонента, повинна приймати на вхід повідомлення та відкритий ключ адресата (і тільки його), повертаючи в якості результату шифротекст. Відповідно, програмний код повинен містити сім

високорівневих процедур: GenerateKeyPair(), Encrypt(), Decrypt(), Sign(), Verify(), SendKey(), ReceiveKey().

Кожну операцію рекомендується перевіряти шляхом взаємодії із тестовим середовищем, розташованим за адресою http://asymcryptwebservice.appspot.com/?section=rsa

Хід роботи

Для генерації використовували простий перебір чисел від n до n*2-1. Генерується послідовність біт заданого розміру після чого алгоритм перевіряє це число на простоту, якщо число складене, то додати 2 та перевірити знову, і так поки не знайдеться число просте.

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Генерація простого числа 'р' ...
[*] Number 0x32b84d32f15c8f3befe61840efdab3aaa33437eb4d10a4498b0ad0d7a19f2747 is not prime
[*] Number 0x32b84d32f15c8f3befe61840efdab3aaa33437eb4d10a4498b0ad0d7a19f2749 is not prime
[*] Number 0x32b84d32f15c8f3befe61840efdab3aaa33437eb4d10a4498b0ad0d7a19f274b is not prime
[*] Number 0x32b84d32f15c8f3befe61840efdab3aaa33437eb4d10a4498b0ad0d7a19f274d is not prime
[*] \ \ Number \ \ 0x32b84d32f15c8f3befe61840efdab3aaa33437eb4d10a4498b0ad0d7a19f274f \ is \ not \ prime
[*] Number 0x32b84d32f15c8f3befe61840efdab3aaa33437eb4d10a4498b0ad0d7a19f2751 is not prime
[*] Number 0x32b84d32f15c8f3befe61840efdab3aaa33437eb4d10a4498b0ad0d7a19f2753 is not prime
[*] Number 0x32b84d32f15c8f3befe61840efdab3aaa33437eb4d10a4498b0ad0d7a19f2755 is not prime
[*] Prime number 0x32b84d32f15c8f3befe61840efdab3aaa33437eb4d10a4498b0ad0d7a19f2757
Просте число сгенеровано 'р'
Генерація простого числа 'q' ...
[*] Number 0x4a10008035598b8d37ee014105966ac21e4f81fccce642c56a8cfe39ccf2b603 is not prime
[*] \ \ \text{Number} \ \ 0x4a10008035598b8d37ee014105966ac21e4f81fccce642c56a8cfe39ccf2b605} \ \ \text{is not prime}
[*] Number 0x4a10008035598b8d37ee014105966ac21e4f81fccce642c56a8cfe39ccf2b607 is not prime
[*] Number 0x4a10008035598b8d37ee014105966ac21e4f81fccce642c56a8cfe39ccf2b609 is not prime
[*] Number 0x4a10008035598b8d37ee014105966ac21e4f81fccce642c56a8cfe39ccf2b60b is not prime
[*] Number 0x4a10008035598b8d37ee014105966ac21e4f81fccce642c56a8cfe39ccf2b60d is not prime
[*] Number 0x4a10008035598b8d37ee014105966ac21e4f81fccce642c56a8cfe39ccf2b60f is not prime
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[*] Number 0x4a10008035598b8d37ee014105966ac21e4f81fccce642c56a8cfe39ccf2b615 is not prime
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[*] Number 0x4a10008035598b8d37ee014105966ac21e4f81fccce642c56a8cfe39ccf2b62b is not prime
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Генерація простого числа 'р' ...

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[*] Number 0xa2e7cd9b5c9541dc49aff069953bf5bfd44313f4a8ad4c1972e8eb41660ec32d is not prime
[*] Number 0xa2e7cd9b5c9541dc49aff069953bf5bfd44313f4a8ad4c1972e8eb41660ec32f is not prime
[*] Number 0xa2e7cd9b5c9541dc49aff069953bf5bfd44313f4a8ad4c1972e8eb41660ec331 is not prime
[*] Prime number 0xa2e7cd9b5c9541dc49aff069953bf5bfd44313f4a8ad4c1972e8eb41660ec333
Просте число сгенеровано 'р'
Генерація простого числа 'q' ...
[*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d39 is not prime
[*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d3b is not prime
[*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d3d is not prime
[*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d3f is not prime
```

[*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d41 is not prime [*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d43 is not prime [*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d45 is not prime [*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d47 is not prime [*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d49 is not prime [*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d4b is not prime [*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d4d is not prime [*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d4f is not prime [*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d51 is not prime [*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d53 is not prime [*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d55 is not prime [*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d57 is not prime [*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d59 is not prime [*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d5b is not prime [*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d5d is not prime [*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d5f is not prime [*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d61 is not prime [*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d63 is not prime [*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d65 is not prime [*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d67 is not prime [*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d69 is not prime

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[*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d6b is not prime
[*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d6d is not prime
[*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d6f is not prime
[*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d71 is not prime
[*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d73 is not prime
[*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d75 is not prime
[*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d77 is not prime
[*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d79 is not prime
[*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d7b is not prime
[*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d7d is not prime
[*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d7f is not prime
[*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d81 is not prime
[*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d83 is not prime
[*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d85 is not prime
[*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d87 is not prime
[*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d89 is not prime
[*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d8b is not prime
[*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d8d is not prime
[*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d8f is not prime
[*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d91 is not prime
[*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d93 is not prime
[*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d95 is not prime
[*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d97 is not prime
[*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d99 is not prime
[*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d9b is not prime
[*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d9d is not prime
[*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287d9f is not prime
[*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287da1 is not prime
[*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287da3 is not prime
[*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287da5 is not prime
[*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287da7 is not prime
[*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287da9 is not prime
[*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287dab is not prime
[*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287dad is not prime
[*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287daf is not prime
[*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287db1 is not prime
[*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287db3 is not prime
[*] Number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287db5 is not prime
[*] Prime number 0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287db7
Просте число сгенеровано'q'
```

p=0xa2e7cd9b5c9541dc49aff069953bf5bfd44313f4a8ad4c1972e8eb41660ec333 q=0x232f1ba7717637fdb9afc11e74cc126f9061ea7a8b4dfdcd09dbcd232b287db7 n = 0x1663ab43fd4876c0f4bb44e1523ee0392febb5d0fe2d24f4606146334f8ba740cb2c857b5768255302f695cf91e204bfc994d719dc27fa352bb10ea63ad57075

f=0x1663ab43fd4876c0f4bb44e1523ee0392febb5d0fe2d24f4606146334f8ba74005159c38895cab78ff96e44787d9fc9064efd8aaa82cb04eaeec5641a99e2f8c

e=0x10001

 $\tt d=0x14af5897a3f5c2e15a3979d5c22a9cf5b8b4487221a28bb5cb2593b9ec0fd6216b911f978c30b5ab4057a3e80236ff04587cceec3c1bad77c45c4d04b5349431$

Testing RSA

Відкритий текст: 123554323

[-] Шифрований текст:

 $42257\overline{3851195962241928524791661039032899696629914952957619505926390487598904717642695243312778625686135350408290304694157149020445580514132910969499245468$

[-] Розшифрований текст: 123554323

Підготовка даних до відправки ...

- [*] Відправка ...
- [*] Отримання ...

!!!!! Верифіковано! !!!!!

Get server key

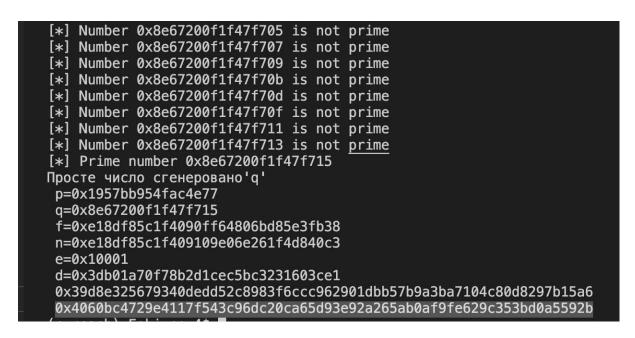


Decryption



Перевірка підпису

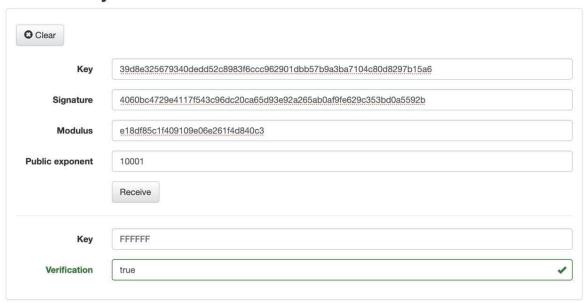




Скрипт показав True, а отже верифікація успішна.

Перевірка відправки секрету

Receive key



Наша програма успішно обмінялася секретом з сайтом, що свідчить про правильність роботи скрипта.

Висновки

Ми засвоїли основні принципи роботи протоколу RSA та навчились програмувати його самотужки. Навчились генерувати великі прості числа за кількістю біт в них, робити перевірку на простоту за допомогою алгоритму Міллера-Рабіна.