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Фізико-технічний інститут

ЛАБОРАТОРНА РОБОТА №4

З дисципліни «Криптографія»

Виконали:
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Київ – 2020

Мета

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.

Завдання

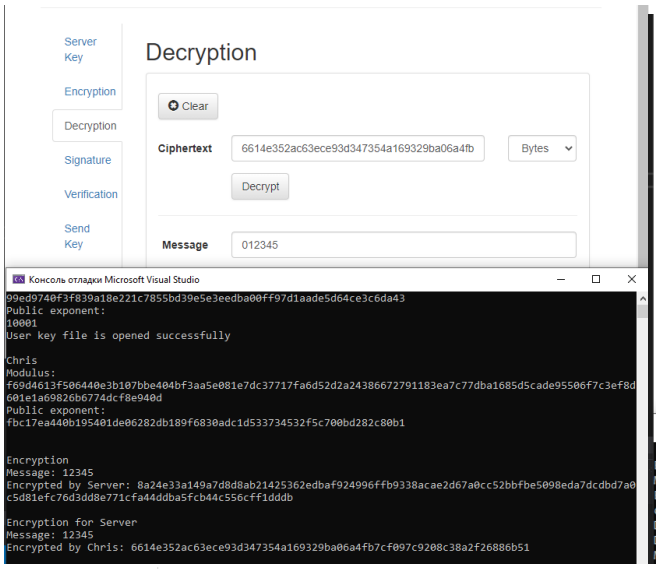
1. Написати функцію пошуку випадкового простого числа з заданого інтервалу або заданої довжини, використовуючи датчик випадкових чисел та тести перевірки на простоту. В якості датчика випадкових чисел використовуйте вбудований генератор псевдовипадкових чисел вашої мови програмування. В якості тесту 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 і довжини щонайменше 256 біт. При цьому пари чисел беруться так, щоб ; $pq \leq p_1 q_1$; p і q – прості числа для побудови ключів абонента A, і p_1, q_1– абонента B.
3. Написати функцію генерації ключових пар для RSA. Після генерування функція повинна повертати та/або зберігати секретний ключ та відкритий ключ . За допомогою цієї функції побудувати схеми RSA для абонентів A і B – тобто, створити та зберегти для подальшого використання відкриті ключі , та секретні
4. Написати програму шифрування, розшифрування і створення повідомлення з цифровим підписом для абонентів A і B. 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 .
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.

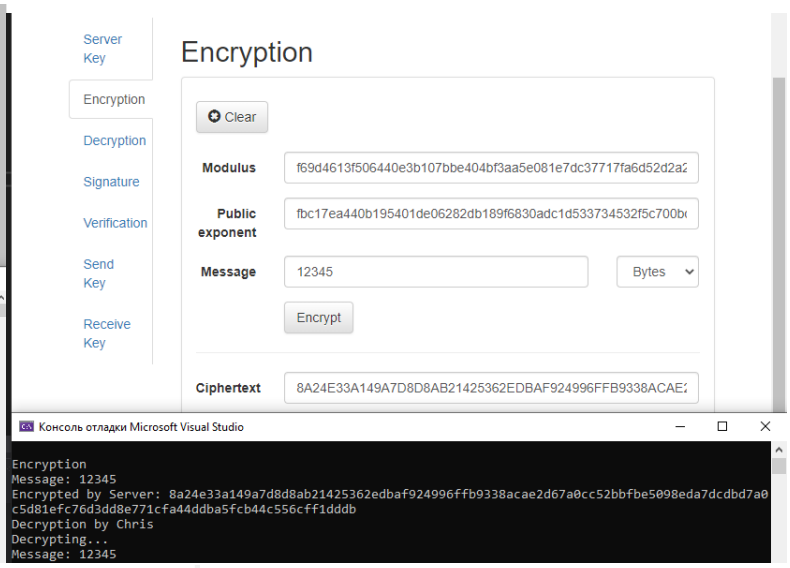
Хід роботи

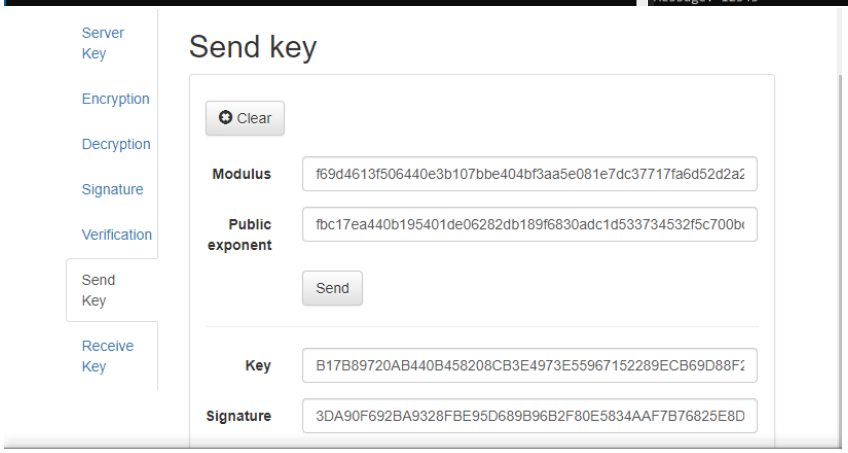
1. Пошук бібліотеки, що дозволяє роботу з числами довільної точності, та ознайомлення з документацією. Було обрано бібліотеки boost.
2. Реалізація функцій пошуку псевдовипадкових чисел, функції тесту перевірки на простоту Міллера-Рабіна із попередніми пробними діленнями.
3. Написання класу абонента та реалізація методів цього класу generatekeypair(), encrypt(), decrypt(), sign(), verify()
4. Реалізація роботи протоколу конфіденційного розсилання ключів з підтвердженням справжності по відкритому каналу за допомогою алгоритму RSA.
5. Перевірка кожної операції шляхом взаємодії із тестовим середовищем.

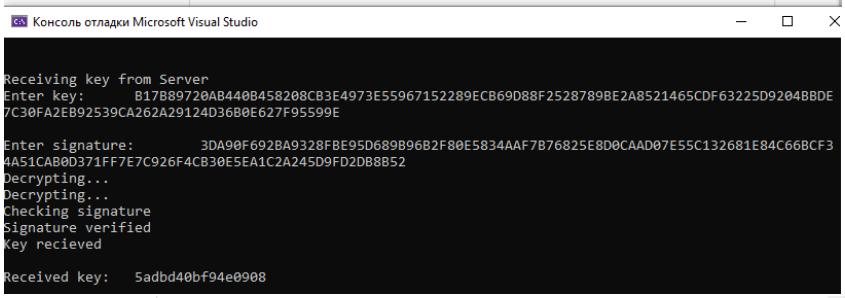
Опис труднощів:

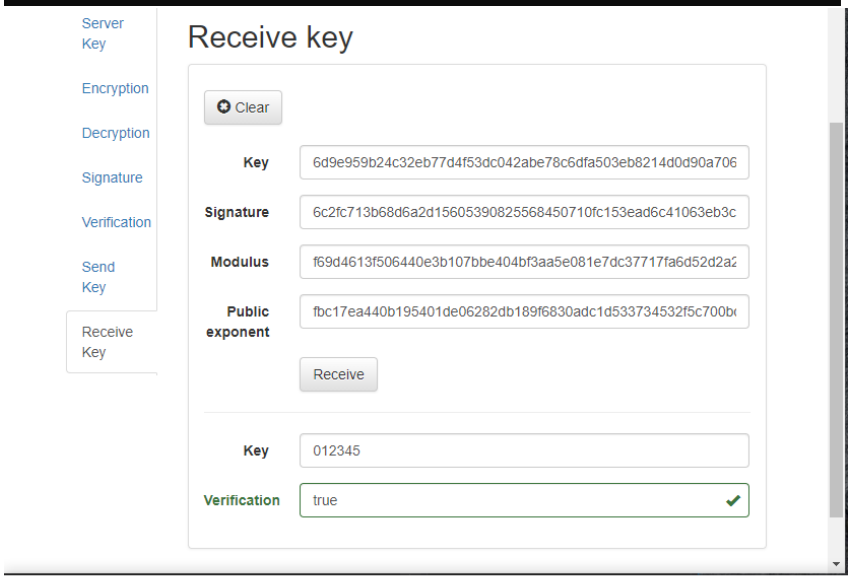
1. Функція перевірки на простоту за Міллером-Рабіном на перших порах працювала некоректно, тому p та q потенційно могли будти не псевдопростими, що заважало коректній роботі методів класу абонента.
2. Не одразу було обрано правильний тип даних для зберігання параметрів ключів.

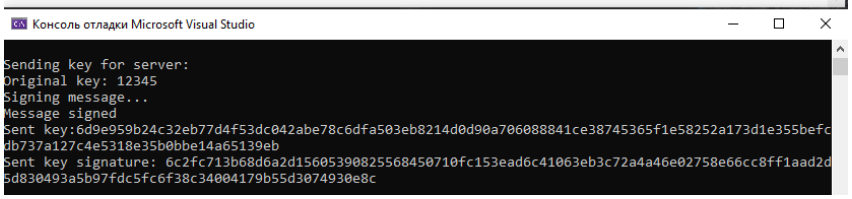

Server Key
Encryption
Decryption
Signature
Verification
Send Key
Decryption
Clear
Ciphertext
6614e352ac63ece93d347354a169329ba06a4fb
Bytes
Decrypt
Message
012345
Консоль отладки Microsoft Visual Studio
99ed9740f3f839a18e221c7855bd39e5e3eedba00ff97d1aade5d64ce3c6da43
Public exponent:
10001
User key file is opened successfully
Chris
Modulus:
f69d4613f506440e3b107bbe404bf3aa5e081e7dc37717fa6d52d2a2438667279118 3ea7c77dba1685d5cade95506f7c3ef8d601e1a69826b6774dcf8e940d
Public exponent:
fbc17ea440b195401de06282db189f6830adc1d533734532f5c700bd282c80b1
Encryption
Message: 12345
Encrypted by Server: 8a24e33a149a7d8d8ab21425362edbaf924996ffb9338acae2d67a0cc52bbfbe5098eda7dcdbd7a0c5d81efc76d3dd8e771cfa44ddba5fcb44c556cff1dddb
Encryption for Server
Message: 12345
Encrypted by Chris: 6614e352ac63ece93d347354a169329ba06a4fb7cf097c9208c38a2f26886b51


Server Key
Encryption
Decryption
Signature
Verification
Send Key
Receive Key
Encryption
Clear
Modulus
f69d4613f506440e3b107bbe404bf3aa5e081e7dc37717fa6d52d2a2
Public exponent
fbc17ea440b195401de06282db189f6830adc1d533734532f5c700b
Message
12345
Bytes
Encrypt
Ciphertext
8A24E33A149A7D8D8AB21425362EDBAF924996FFB9338ACAE
Консоль отладки Microsoft Visual Studio
Encryption
Message: 12345
Encrypted by Server: 8a24e33a149a7d8d8ab21425362edbaf924996ffb9338acae2d67a0cc52bbfbe5098eda7dcdbd7a0c5d81efc76d3dd8e771cfa44ddba5fcb44c556cff1dddb
Decryption by Chris
Decrypting...
Message: 12345


Server Key
Encryption
Decryption
Signature
Verification
Send Key
Receive Key
Send key
Clear
Modulus
f69d4613f506440e3b107bbe404bf3aa5e081e7dc37717fa6d52d2a2
Public exponent
fbc17ea440b195401de06282db189f6830adc1d533734532f5c700b
Send
Key
B17B89720AB440B458208CB3E4973E55967152289ECB69D88F
Signature
3DA90F692BA9328FBE95D689B96B2F80E5834AAF7B76825E8D


Консоль отладки Microsoft Visual Studio
Receiving key from Server
Enter key: B17B89720AB440B458208CB3E4973E55967152289ECB69D88F2528789BE2A8521465CDF63225D9204BBDE7C30FA2EB92539CA262A29124D36B0E627F95599E
Enter signature: 3DA90F692BA9328FBE95D689B96B2F80E5834AAF7B76825E8D0CAAD07E55C132681E84C66BCF34A51CAB0D371FF7E7C926F4CB30E5EA1C2A245D9FD2DB8B52
Decrypting...
Decrypting...
Checking signature
Signature verified
Key recieved
Received key: 5adbd40bf94e0908


Server Key
Encryption
Decryption
Signature
Verification
Send Key
Receive Key
Receive key
Clear
Key
6d9e959b24c32eb77d4f53dc042abe78c6dfa503eb8214d0d90a706
Signature
6c2fc713b68d6a2d1560539082556845071 0fc153ead6c41063eb3c
Modulus
f69d4613f506440e3b107bbe404bf3aa5e081e7dc37717fa6d52d2a2
Public exponent
fbc17ea440b195401de06282db189f6830adc1d533734532f5c700b
Receive
Key
012345
Verification
true


Консоль отладки Microsoft Visual Studio
Sending key for server:
Original key: 12345
Signing message...
Message signed
Sent key:6d9e959b24c32eb77d4f53dc042abe78c6dfa503eb8214d0d90a706088841ce38745365f1e58252a173d1e355befcdb737a127c4e5318e35b0bbe14a65139eb
Sent key signature: 6c2fc713b68d6a2d1560539082556845071 0fc153ead6c41063eb3c72a4a46e02758e66cc8ff1aad2d5d830493a5b97fdc5fc6f38c34004179b55d3074930e8c

Enter generator size: 256

Key pair generating...

1f54a9b57eed94c9ebf1ba4290645c7565b16c32ba764eee883cf9d9c1f93b62 failed trial division
83573f41f25328e30ab898b3f63ae74b9f81c4dc9410e36f074443d0a9649c5b failed trial division
b07df8f80c7d2d3f3288e571d2ac4b5a05879ae8c2f90f7964b77470f78728ce failed trial division
691087ce8c1537661dc54b90aad3af22d3ef1b766255b458eac0bb878cbd68c8 failed trial division
7e7882af3d784ca90bfc9364af28af16d50986d2a04c63530f6268ca693f7fd failed trial division
8b144cb7620a6427d702e0af0812fb1769d1e12ccb9eb15cbba3d8c5c6efe1b9 failed trial division
de97eb9d728d292e97937733650ad334f789ede17ab452243872ea6eb903e9aa failed trial division
cbf31fff71de1a8f64a871a340485c37928a11e5ab9b37c5b26a2d4269806c5 failed trial division
ccdbf0ad023cf82293a99f44bd12bee940c34bd50047bd4aa6ea85824635f8b0 failed trial division
e1f403eaee30fb6866e9961d53abc6cdf62098052d57bca9c81c2c1b0e022479 failed miller rabin
4c64a59d86d5a7e45d0cee58a7f706c405ee5650ae979fe9206c26d9f298b2a5 failed trial division
7fca5dda71671d763b33f48fab2ba8a6d376dbbfdc70e103787a56f8090d2eca failed trial division
ffd6eeacf3dd222bbc32d47179bac2f70de580a30440f46348d225ae64444b29 failed trial division
fee09d9f5e8d3e5c05b8efb54a77d37223b33c3534be48fcb4ead2dcfc142511 failed trial division
524462e7e767c49ee0ae0d981d08b44b726f3aef7e90400fb2a9a22c33937dba failed trial division
8c61d783802c09429e8b0db385db54c61c9d5e6ef6a0212e775f1e40efc2fe4d failed miller rabin
d2c8d606dac28d269246682e0f1d5bb2e13e617ba1b9478d388d9838955f6b85 failed trial division
8ef9d6e3aaa9e45c96ac0cdbe90fa8712062fd62f2985665757d3feec66a00a5 failed trial division
eeaa1929ca7060c3ba758e0de8b3e717f83de0255a4094de0853341ebea0da61 failed trial division
315355bb56a5a1d1b46c294c90baab6b94af609296ce44645342e258214becd7 failed trial division
e7eb78987064fd4cb26204bc81fca8dd80022a0b8f3a84186efd2e5edb196a1b failed trial division
5a9e127f0d764d1872db89e692611aa5d1bfaac03259128ef25d372c47a142ef failed trial division
b448e2d3b30c4e1c5e6943b720f6c08bde01b9a1ee77552661c5e21620ef1a7f failed trial division
6728e29a65c29398bfc75c598926ff90616e6567319317fdcc76bb5f2c37e3ca failed trial division
605d456ad7c4620a933afdaf5fa060fb3ba34d66dec0cbf4790497853d93b19 failed trial division
a47061395721eb4d3eba1806bb92d87f01b0399fc51613f31783dde3d53d6585 failed trial division
3c9585ca6097a4920ac66d467140d56e6c11f4a1f206351bcc9f3c635fa76bd8 failed trial division
cdb3830757ab6a1ec325d2690538e20e8ee85b8da36da208d4bf805079c0a249 failed miller rabin
d134c5c8bf4a09dc7ac0ecc2257d60b57801690569bfe1f06239df689eea351f failed trial division
8e22e0a9e4ea944ee52c9819f8dba2ef04fb3bad2dcf741b6c15f79dc80bbc26 failed trial division
ee09c14caaaa255b15648f7197598a81f697ac53fd0d0754b064ef711e421e2 failed trial division
924b762472d512dcd12a5f5dbea3c1ec1901d56db02116b680f0d95633b4500c failed trial division
cacc32f06cf91157dbab1f006acac33704bf523240871d9ad48163c217e5a6ed failed trial division
cc51a704b8b3cdd61f7765bb49cd1ac3a47c27f136a36f1b0ccbcbb7fe83060a failed trial division
aa7629e0a8710b23a4adefc6edf8e7936f5cfe74b1a142a13240fa85b6116a49 failed trial division
98e072731441cf3cdfa636a5f54cd15f5393d0c84e05d800b6e9c27d8d9d4ac1 failed trial division
ecd70deecfc4a8474e1d3d40b7cb97b8a95a20bcc7a880e54c61413e35984203 failed trial division
36d085ae8e06e969a411244e26823ee7a2dd8439a0fef02dcebad77201f5db6 failed trial division
99ee60dc68f711932311400da3dd18557067165b18bab672000cf55f578daf00 failed trial division
7943eff3f19d3eef59f4c796e91dcaf95a9e9b56e720d51fe73bac35f473edc3 failed trial division
839ec50a56385238a6822368e1c7cf6744eba7eaaa816ee1298ea4bf5b55f2f2 failed trial division
a3dd8ef0e03b6b21aeec2aba035974dc8b09043a650c562f209ad980d82cfa4e failed trial division
f23cf581e7aeb48fe3755159e9541a7b35afd31a5b122c8c0ea703dc99d2fb64 failed trial division
7347f5334d19fb0cd719dfcdfdd6752754f87092c6987876ecbcf58786cc56e9 failed trial division
1da4dcd205940f3040928cabfe16f80c17d1827bb6e011abbf5cc2339859c46a failed trial division
67624799e5233c4a58c47fe4ba5d57bf01587a6796526227d29dd754bc524150 failed trial division
88dc4772fbabc7a1975d983c5c9ddc1c944fecfaff77a886a37e828e72ef463d failed trial division
d5e826cd69c9cbee3c0c9537b533006a6a4aa9815c9d4becbb3d34f9b024aa1d failed trial division
195ac9dd58e28562e49f9e4a15eb694cd8135e16f70e16afd9dad7dad4f4babb failed trial division
a0f32d35aa03a5aafee106567d5492b1874112028852d691fbfbd022817d958 failed trial division
e43d345f4dc14e3d5eeff65d0bc1ab74f23995f205e4f78f8e27b261ff8038b5 failed trial division
f4c3be8e4962e12994a6f129c2978355a5546fbc75b2493a76d6140a549baa3f failed trial division
341890c0a658e82b15a046029e7ec95748aacd7e97ae4ca8df2f76fb4049b3fa failed trial division
90fe9e1f339444cd673099f55bbe244f2fe50980fb571af9fd47dce2926e0775 failed trial division
b1b32586aeee048a146c61a43edb62157da6eb9be19efe3f4938d6e9b0afc51e failed trial division
3f7c976afb6c153d2ca6cfb8dc744196ba4979da76cceaad3841fbbf2ea064d4 failed trial division
352e65f25ace7779f5c3a56a93b53656176f202ea7aa7fff60a3d4fd184b018e failed trial division
8e61a479bafc55c9920cc7dca46c591b9ddec843a10bceb50a8ff0133f282c95 failed miller rabin
987ef10c036dc5fd49305f6b39ccc0afd2b0932dcf4cd8fd08756c004bc4723b failed trial division
e6d84b72296462243a34564ff0533b11103f7b28f8318d8cc1a5ff5e7e050 failed trial division
343783eb1852691fb23c3fe6c4efc5cb35ec829e49136948bc41dcd9104333ad failed trial division
57e373b2a782e1213ab109d079d37b10169b1e040b8631231b00d3f1bf58fa44 failed trial division
40e54d9f45f36675503baf0c21331dd3bc957f77ecf5a6edc6693d55a1d5a9b failed trial division
673e287f1de27c89a30b7055d212d0da5d1f3f7072cf38e2f8be370fbac4132 failed trial division
2c0b85c21982e0b423b7b09cff615562d6e519300d8b21a6a640859b809f91e failed trial division
abf9d66aba161be81f92821e5419e5973134abe13dc93f5767be7baacaf63351 failed trial division
4d333c21ca7b3d7c3156145b13cd8564e540ecc79d17d71230bfbbc4c52b6b2 failed trial division
2382b1671c3f6babb106cebbb59e5aa59be429cf4cfc9ad550543cd246efb0e3 failed trial division
a187070cda3743d5cb03bb9489a80bbc1ce2badc9e1129628f896ce970b05c failed trial division
7b32d9ab7698ed309224bad85169cbe95bf345aac1873c87d2fb876816377ae5 failed miller rabin
62fb9cb37f0c6bee0464a3aa8ea5f435e8ba72dcca4f3ae44308f6eed93bd82 failed trial division
9d639cc9d755c3ce53b2041610cbfd34b11a957a4490dacb814d8f19e5a37a3 failed trial division
f81e2334e16f70c567b7529aa77a9066e85d55d74479af5ba05f569c9c7b4a8 failed trial division
e6701fbd3d3737affc640419265d8013536d028965da7c825c8e4dab1c9a0e2 failed trial division
b61e5e8bc565d6dfc3d10706faf68fe77150023663dbfa260aefad521eb4692 failed trial division
932ae309f573319270b30b505d969eb9ab7c47c6a32e2fc86504754deae0ed3 failed miller rabin
67c539bfd62cd1fad591cff75f93b5dc6f8f30447bdc0609786ac24e1fab9e failed trial division
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b07b99d0c903a46b0534f4312432aeb34ac1be25940e4d103dbb88569557d3d5 failed miller rabin

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d6aa28e7bffac19e9bc7c5848fa5bef913b8a6a8637c8da1446892cfbcc8dc4c failed trial division
6456a3c671076b758a7614c4be57e55bfc0c41f30efdbf2049bc197d33d63dfe failed trial division
8ddc46c3ecf52db0e61a4d4da65e9696bc7cfdca3f5b85e445dd459f9998444b failed miller rabin
1faed7a84e900ae1fcdafceaeae3e613681736017b5ed3eac46c402a6648ca1e failed trial division
c3f90cbfe215733712e3dfe6935c90965c7a7217bd6b79d480e8f95c561713ff failed trial division
6c83fc3ee36e5e86438ef9af0cb21af5c93ef03725b4c145acfbe4e4699846a0 failed trial division
9ea722d36c57ea557c39683af81772fa3cc975042cf3e20761f2e4c1d3d85da3 failed trial division
718843a116137f5a8225e79412506c8efcb4e25872caad1931cc7e3e7c37fcc1 failed trial division
df60cf677485aaf3fa9836e7546fe00f11e209f842b1c2c24e2c0b5d88caa0dd failed trial division
ef73fd84f026cbe9311353999974c5567f88b99d84ed1a3e395a663ed1d6436 failed trial division
bcbc0e3646da951479c294b62c5aedae35270a8b7baa65ef8c0d52095d571d19 failed miller rabin
7bb3da5ab4133b73a62ec55bef2f1e612116513ea19c766144744d12c7bb8872 failed trial division
3680faac5e8c6bcd358dc0c364fefc7ab3677a9122386170ec9113d5ca1b9518 failed trial division
08b29dc4b29ce9e6cfeea3ecd3cd5f2b45e24ac0050d73a6f8185844a02c79e failed trial division
8df8d44d17eefcacc6c68b388ae4d6057aefad3a8c6e89e0ab6d3db513d71a04 failed trial division
f2de59cb48c5415d9aaf5259de17187b74c05b2d4337b59e3c27f38c18b46db failed trial division
5a9bf384ec14ea448c10106cd582b4464098921bf743bf139cd2d49a5f305f18 failed trial division
f92507eeb1f433bc172d81eedb70fdc6f7ec383433349b984c8a555b1cda04f failed trial division
b872985baada7f9e980b2cd0a1246995fbeaf81b06ac0f15cc679e1fd5870f43 failed trial division
8c1d56fbb34700b72239c03742cbf0c0afdb9be5070ed54e68937a4d63bb437 failed trial division
45f6d3bf4c4089de6ad200ea02ae5a0ababc0dd9b73578d579a011040c160e1c failed trial division
8285165277ee1aaeaa82383382be25392c431c460f3a60f69a5ebcd16d7fdc1 failed trial division
e9cdb079a391d827a8d51a6dcf5794d5669a73a1330dc6ee1f937996c7a2a53c failed trial division
ed7f2e479968eb066f3f026799366370423c2db2bc096fcd1e74048b106ff65 failed trial division
88aa0b131a131198ba422b657b5ddd791fc2e6836a0576a90dfd18a8439a80c9 failed miller rabin
41961331062b760fb4c8c5278df82a38283f8c7689230e2f675c87ffc7beac16 failed trial division
b06f9cd75cb755af56fc6306049672e99483e44150d9a431c86475f9b2cc050b failed trial division
9b3d92031adad404a096af2c15e2ed6bfe090ac793be5782e58426a757f8af6a failed trial division
75091fd238c7e0e277cc805131d46bba4bb5db81b5f9f3d3d2014d0ef6cdc54f failed trial division
5b0aa538c1ead52c1863c4704e942fe4ac54b14b8297d78d58330d3e9bb2527 failed trial division
7bfe56e9d6b8aa3875e4610f866abdc79943db2ef1aa9501a748b4567a873303 failed trial division
5a7f0ea0bd967818104424a89d8140bf3a2906e818f0a854ebedf73f37ccc82 failed trial division
ea42af1c3180d4d0546e5c82cc039ca5a7aff253fca58d1981e3adf9dc80f4dd failed trial division
30df440fa9f9aeec35691cc757da9e232af22a30ecef10ba63663920655bf655 failed trial division
af218771fb97d393882a54e300dc40ffe4b212edc139d85612d95baa3cbb1aa1 failed trial division
d19b260f1fb4fc50a4f90d15b627213d697e2137aa62035df23437503480f64 failed trial division
39b814a7b693c531e09b534cf7ead89e1dde000ac3a175c739c0e5d86d73746 failed trial division
dde48fb1b450907e5880f6450129956e7502b1e1a8390be9986fd95e33ebefad failed miller rabin
97bc2f5d972d49aa77efcc010876e6b6fcd745b08e34942aece5c65d75737f20 failed trial division
8c0e72a521670345c0b7b5fe8b73e563d50b851dfd8c88e7b17a321a95955a3 failed trial division
f9de98c5d935018d41e33ea680aa906fd9f339164c435d60f4c8794570aa77ef failed trial division
febc1c527056c3c566647a4ca8d283620926eb1999f265168e4a9c2e4a72661 failed trial division
cc9aac1d99aa6ae4067d22b9f7d5f6608471d9eda272654dd1e3cf6b7e9addfd failed trial division
579104d74f09b82ed445014d3814068a435ab82d124c46cc905261969c36995a failed trial division
2316e2de9d53b41a4ba7ce62c8550fba20061f2f8fa6be323456f2544716bde6 failed trial division
d81f51e25668972f01b013f2597abad5cb3a4cebfd0088ea7b5b1f92bdefba95 failed trial division
216302e6d9b6e74bdf3e36828ccac376924662d9139c3ef8111dcf81d8174d0e failed trial division
cb810f1431d8e77dd13b0df1b8bb9324ea637ea49c44af5b821bfaa3663d15d failed trial division
abc401d86cd343e96318374c0453ae85721a859eb5c5e4c3754f312e530a5455 failed trial division
4d245b2c1a300f847f93ca637ed2d089cb10a29b018b7d7765107a6ca8a18203 failed miller rabin
fefc4b9cceb48fb25f290f7c604047d0327cbb82a44f19c6098ecbb092a24775 failed miller rabin
2eb1e6074c452dddd0b25821426d7f1e0ef7b37e0ca0ffeb2116a52aba9db18b failed trial division
7b5d1abbb0a3c1d9f2d502f770a3ae79f93488290829f9f117f5e2f1ab41f1a6 failed trial division
5bb40070dd3d1b6994182dd9ca36c497b0fe12b6df1606e23d1256b22db9cf8f failed trial division
a57e3dde5c564506f1535de3662f3a7bbc03e71a4837a854d19913d7b3ed1f7b failed miller rabin
f9484f642eb4410b3ff637e5464078c4c76e2c768b72f157ce5cfe56e6d77f52 failed trial division
3195c3040f40ae6254fead32e1c982ed2f09897b7c64b1997cadcced2e0d9ef5 failed miller rabin
3734772d119fc4bf26605ab3777954b9774f51519d56591a10245d0832059f18 failed trial division
f25b6cca3785b040143c08dc3840c38d378aa4af70287ba17ffee900c8be5234 failed trial division
38586d50055dd622d4e299a74f93001c3d9d9b352e61477a77cd1725df382f3e failed trial division
7b35825cafb877ca965e6f23c0892e1354b347293c81c5cb5e31513e60900eb2 failed trial division
a552705ecf3518e558abb32f0671113a47afa2c3b5914a695c44d702cd33d9f7 failed trial division

b4c2040e288e1e56e0faef1850bedce02494740f0ebf3754b38cbdd7f2b52476 failed trial division 3ab68112a8a19af37a5f050b5df67304fa6a9ef426a7e7bfaef13dffaf49b4a8 failed trial division

7576844f08e4139b1aec2f65269a85063b0e32c08e26c46c692a1a90ecf0dbe1 failed trial division 90062816628222f8c0513942dc9278129551d61a51e9db978b85128895f93707 failed miller rabin

157486fbe65445a4d4777dacf55bbab8009180d142b88811d126cf23636b40ba failed trial division cdd186addf4af8d09271e5e7dcd24a992953c42742ec4b752d9d4431c632a6ab failed trial division

da8e9b5f40e1a4e8578fd4342bec019ee7f0a616c21905833d492fd49256dd42 failed trial division 7ff2decb5cdbe16915aa93856519f60bd39a231a8d92e851117fd2a1676eba86 failed trial division

9b3855f0fc6d98c752d036afd29f5cc7671b6b757e036580f39d60b1184596d6 failed trial division ab900ef6ab8d4b594525a18af472c9e5d53da335a988853c30d203f263b395ef failed trial division

fb6bafd3d0861c8b126e62bee79dd2d160038edcfd3ac5dbf76ff3a67cd03d3 failed trial division bbc7eda7034075e6ca64a94ab9c9d0bb194166cfb939ee18a850616ffd90915f failed miller rabin

9750e5952a08d8124891fa3457bb7c56bfa39a78cd883076d62f86df4ae0adf4 failed trial division 7093b213e76d9158192dea9b026080af0904125666e3852208399d82208613d3 failed trial division

27c3d1b13c295aa9cc5eba9807800606ed6f933ee7e52178bfe0644eb19f83c7 failed miller rabin 6eeab85ded1805d042f9feba7ddd3f29c5649a8d36fb3fe707b255c4c864ff55 failed miller rabin

b28b6166fd155725e9833cdfc78b71e8a7a91c87b1af3fb6e598cb49087e78e7 failed trial division 28ea27f44edc462a9f26b0b25cfb6ac9ffde63b560ced2f14958308287bac4e1 failed trial division

72174830516b1cb3e04687d2c4891499a1563f8aba8400aa15eeb3a2fdcfc238 failed trial division ad24a758e5562af6ac1bacbf1acff509d6794825e5b2fd382788ca9bd9a241f1 failed trial division

4e58741e5220e398fa3d19c5c41d3b28a97b61a8b777e6e9faabcbae842b7c10 failed trial division 6ff6eadfbe80654a0e0e2da4af757e27e54201f4b8c5d3d2080e9279af820c4c failed trial division

b1cd26e118ff83699b187daee23d5bc4b36a67aeac8a2d038ca39aa686f05e97 failed trial division 79e2175b675a7cbdbb4c664f53de15047e2313bc81c51bb529f4bbdb208780d1 failed miller rabin

547892ac90dd27cf6ee7878778d87b3b6463f9620f279d9bac519bbb0534bf3d failed trial division fe4c97c50ba99981b2d20b19d9f1ea1059383796c003d909129cf0107078fc6a failed trial division

42144aade684673f067e6861b7d06f93e4e5fe358a7434719811e811c95b54e8 failed trial division b1a5930300b74493063baf0c0ee2d20843c4091c3d547701c5c22600bbb20471 failed trial division

6a28c2a67c940663adb29848e8fd07425360de298f8d23dac038603e6268e1e0 failed trial division 2bec069014277ba40d340df6227c361421f5294a57aa351a7e4cb7992eb24af9 failed trial division

1c8087a950372648ef237c1cb2509c99b9d83fff4b32273eb45287ba8d1a9a9a failed trial division f8e3a387a52197e7c66187fcaadfb6401a8d3677e554ab7d97ce05f8b810208a failed trial division

72781161d62fae221e9b205f25f12d8beaac782b46adfa6fc8dac379c1cb9813 failed trial division 58c9f5fc7ccec965799297c50efd9a491e5ddd0184bbf18ee5815b8b1cfaa5b1 failed trial division

55d82fb7c495c05f5e024e16a47a1e2028e0bab6409c7b4a3ee905cc29daeba3 failed miller rabin 24a87c73dcf5a5ee9dcb7db33a27bd3921c02a4cc535a2263dba38f0cebd43d failed trial division

25190acfe0519fc3f229dfffa4b0cc5e1239978eac4b9406f1ae34ccc73fc9f7 failed miller rabin ab4f197ba3229580f1306c1a90300233639abe93a47d3a1b783c07e264001e46 failed trial division

9635836d78bc3aeb51ab9d1decf68b9de2c02e80455927cb9cc7b3369b00aa7e failed trial division 45b9f94cc053a791552d77fd4a8e44775ecc3f74c83804a0f0cdf0756c30be4f failed trial division

9e07c616162dddc0c27e1cd76a2a0a1885a029428a450d2d7ce3660700dca513 failed miller rabin 9608102e86bb0bc47685f25be6580f5c52246b6e36d2d2b168ece881617832bc failed trial division

2918a8f98fa7aceeb4c91479f0984d39ab5acd0b981674ae2241c5a0fceb923d failed trial division f4f7d96b09658d954480caa2709ee5f6d49450d9ea155cea6234b488f611f583 failed trial division

5813de622df1221e75040a3a6b8aa3665cdd4230bae8ad73b7ad16eeac86cc94 failed trial division af7a68aa4bed8f1b68e8fad37e746791e780e1a59cc0a613aa984a3c8c4b4e41 failed trial division

fd03ad30ded32c17df2850b3fcfc23036256ecfcafe0da10f69afd08fbbe99a1 failed miller rabin d5fb8e9db0c9f475aa7f5b8bd374f39e8373e1fcde03948d231164452580f989 failed trial division

b9ca603e792011d54623b88aca37e33bc851934189af6ba5a8e6e6ecfbd1b222 failed trial division 2cbf2f79a2a0a2dab5a559c1e62d8e0f19713a87ea57bc1b3dabd4c3865fa07b failed trial division

f9104fd9949043d51d50b6da51f98914dd5e0771dcb77ea8d205d9e0d2977170 failed trial division f498b613018d2672055bfe82e452dd13cf9e406ba8cf679e9aac69d3a3bf0c43 failed miller rabin

5a7cbd0bcae04939798616c33ae3fc4833fa27442a78703c791715cbc788d6e7 failed miller rabin c7bc6b60304d0e26a5d17ed28f001d7f8f5adb116095433b394028d1315f91e0 failed trial division

f9d9e07d0f47c1ad661a4b46b6afb95d2d83232e940e214549dd7f2543f357d3 failed trial division 18c060b632cb80c1656722a9ea3ff68aa3d776305046397cef45ebd831956f19 failed trial division

4263b773b1d1804089a43a292896baf1f4c4091f118dc10007bee8e2ecd12375 failed trial division 8297a9f21c76711e1aafb1da5db24bc407cf9e507da712ed25d77f905d5dae74 failed trial division

265d7c07fd3c96e3eb32a1311148cb42cf4f2bfc6828df0f2777e95d9dfdfe16 failed trial division 8fd271561046c84834d6d3f0f695c70732a2777eeb9aa5eb87e2494057c68533 failed trial division

51317cb15ee7ad3ad507505c4bd87130695a60699424b52659e73d94df35b0a9 failed trial division 4b1cd85ea61ffecae8398cc6a5ec788ff98cf45350ead684f0ed1397b3dbef2e failed trial division

66f1a34942d6231e6bfb21966da2665e8e96ec889d5d6b0e00ae3ae38f079086 failed trial division c3f31fe1257b834e9278d85803df700dc20e69e6d25d381d32294c216445582 failed trial division

e3212e9cce6e15d49a52c4b9e4fc67fafb6fc287aee54d5b207f8fbaa5c0a34a failed trial division f8f6dd4cab9ab6c922976a11adb1154680eaad9ca89c6dbd49cf1bc35637e566 failed trial division

d60207951245585b79362194c86d0ee8975bdb330bf449b4c05eeede0fd59fea8 failed trial division d0f156b8fb5ba54220669fa7f1932279e59a6046d3ba677dfaa97d3b38e096d1 failed miller rabin

62e5731cc2918afa1d7dc976bd76befe151e7f2e98bc4966f81baaa8164829c3 failed trial division fdbcd1c8fa6b97f7d9febad1acc46075c41e1ef5b881a52c40af349bb3dd90c8 failed trial division

46db15a4da2793397365ad9563222493253b63a53c7b6ff1e398d90fef5fca67 failed miller rabin d4894649626bf437b8e4743c2c248125702c5a098a5d0d42fc37b5f108cc7a8 failed trial division

e3458b1a60f267dcb3586b701140dc68a31acb6ad9d3585ebf347c87cdb00169 failed trial division 5015de8b075d487642ce9b51037866155e73a9148d01f26e43525cff9cb61520 failed trial division

1c4016f780c0cc599779d699fab1475fce6a3c092606eb0d675546580b3d5aef failed trial division 1035c9e22ade026a9b64de79dbaef1bfd8f039778b2f0d8f7fb3783c5b8bf468 failed trial division

8824e16161f59dbff565852b8c582d911a1e46a1e4948a9c06c25d02020ccfab failed trial division f27d3c4a4cfe3f37aae3d2a54041619a1d23b3b418f325875a21043f7ba18e57 failed trial division

4efe85998b3ac76f246047ec17cf7d79600a37ef11380900e257076de55c3fd6 failed trial division eb5bc874153fe8a128181e5571267141838e7b90f8f78e50a78264f688056773 failed trial division

75ae70681202fe1929b2665c974a00540d77134b97682e9f0197ed4524839ff1 failed trial division 1e7cd988516b3a06c6249312f543c2dcdcdc680f3922aa6b5d6d4bdaa89023e9 failed trial division

7f755d83a840517c2c5afc9c2564192a0c6361932ac6e1a240bda0f27ad336c6 failed trial division 7210f045140d0f3da6e4552ef3c46a0dedc24132b1a466cf5509b72feea0de44 failed trial division

438218828703fcd9edf5af14f55973697a54e50521076d2755d4b70234c72073 failed miller rabin ebd76dcc75c9a7ccd7613848e9429bea9a3ef02d3d811a5f51cb8fa384e751a8 failed trial division

416508a743109c03f78bcf4223cea179cde31c6dc60a1eb17ede202ac659e957 failed trial division 8bbecde53689b7cf5902bafccb8e3e2a5250c32e495e3197c0296dae0062101d failed trial division

96c3ae5e91489843efcefd218ae25ace36e883073664d65d00a19f69a5ff6f3e failed trial division 7c73e1ed93bfdede30a28b3d795288168c164b2a3fd42c89dc103799f227e772 failed trial division

4765c52f25a65805a20f46459118ffd715b15b91aadc680fbf5995d787c2830b failed trial division 6e0127bcddcd17d9b29ebdd48a480e6a702cbb450a05eec70870a362a57ae41a failed trial division

4be75eb14a901f11b31324495bc0b61f27f30c3a7b945a54331b39defb17f4fc failed trial division 56725eb25afcf62823c568ca1f9c9e5fb27ac66c7bfd1542c52ac00bf4035e50 failed trial division

916f3ba164eb46eba4350cd44b74f7574bcb2fc1b8640dfb7128e14caf0c820b failed trial division 4865821368625**61c5ab8b45caae6f6d8b15ae0a5bc87c078ebfc58d06ba41943fb** **is pseudo prime**

8ea68f6b05b284c612b12b0bf0425e37875cd81794dbe371e74cb6a6b683f632 failed trial division

Key pair generated

```
**************************************************************************

Chris

Modulus:

213ba9040d54ac72ef4f82954f13fa067e40c722e262fba36b8c4f3e35091d12b708d47a06884f3234e13
7916715cbc01624ce91a8b260db104206e53ec4a81

Public exponent:

d56c5f2934ce0702c38f1e7f0d9c875ba14846f742d7835162a9af1b93a92917

---------------

d:1df7710328604a41bee6bb89b8a0a87ecc63ec4bd20e08529a091cdb0ecafd780cbef26f26e1f86c933
f8924795dccbeafc84ceee06ac8464b20104fa6242a7

p:3716b9f7fb50caa6b29262504aee73b811a26639491cfa8e2337e9e547f7a6b3

q:9a6f7a2bbabab2b9c7a631a63ce6ca87c8c5ec8a7076347fc58d06ba41943fb

**************************************************************************

Key pair generating...

///

c997ac737d8996743fc2ef6e6196629510262888c67b5f2809797631dd87fca3        is pseudo
prime

///

b9c892bea3e769a8ffbf7e779e1ce0767ccbd257f8c9fd1a56d21aeaf65534cb        is pseudo
prime

Key pair generated

**************************************************************************

Den

Modulus:

924c8daccff02a65a09ff2b87796b5df5846a4a9dc1b206c9a8c0ea3144035122b552e24c15de90a707f9
e4263fdb4c224b586fc6160b5a2a66d9073ce457141

Public exponent:

8800b6251c9c5c3f191578c76bf930cad822ca0fc987d50f581fbea2237ee1d5

---------------

d:3cfe1ac230a281a17cd171d1d182a8823b8aa6f787cdca5f0a9d3e0bfb91e3267b36810d73410176734
bf14a7d542b9b895d88323b2a3525a9e817b9d69b5561

p:c997ac737d8996743fc2ef6e6196629510262888c67b5f2809797631dd87fca3

q:b9c892bea3e769a8ffbf7e779e1ce0767ccbd257f8c9fd1a56d21aeaf65534cb

**************************************************************************
```

Chris signes a message

Signing message...

Message signed

Chris` sign: (123456,
dde3ceeda2e93a672678fc98a6ad22180ba46c7cc3b7d53ccb14db08d5ed01db5448660cb04427d36b8b6
21f691b477117e4155ba7e2ec1a8aaa0cf3a894d7)

Den verifies Chris` signature

Checking signature

Message: 123456

S^e mod n = 123456

Signature verified

Chris encodes a message for Den

Encoded message:
1f2115ca09718050a9e3fdc331576f6185cc0faef818c456ef26fddef862484539c0285c892ed205025e5
a13445a27bd7644b47e4bdf54ecaac3b25c849d931

Den decodes message

Decrypting...

Decoded message: 123456

Протокол конфіденційного розсилання ключів

1. Абонент A обирає ключ, який він хоче розділити з B

```
Chris sends key 21122019 to Den
```

2. A підписує цей ключ своїм секретним ключем

```
Signing message...

Signature for key 21122019:
108f1e1875155d184585cc56d60cd199b8daccf1731b419f9f4531e268d220b6ad8c819067c964914f695
5c759e00275bdd884b8cda7970bf4e5258e5dd95e
```

3. A зашифровує ключ та підпис ключа відкритим ключем B

```
Encrypted signature:
836c1ff792d1174f03b080381b25247dcf59ffc065325bbea4fae0616547cd54a47c0d437d33d70cb7b36
cf38bc8d22ca1e9ff3986ad0b3bd661a1271ec3e509

Encrypted key:
355d02d23dbc0345e9caa1866ac91a1f1181c62dea2e6edfd346429915b49e67bf53521c02c178a24b22c
86d6e5b65b8a46c2cf8f53779f07a39352baa7bd8dc
```

4. A надсилає B пару значень (k, S) по відкритому каналу

```
Chris` message:
(355d02d23dbc0345e9caa1866ac91a1f1181c62dea2e6edfd346429915b49e67bf53521c02c178a24b22
c86d6e5b65b8a46c2cf8f53779f07a39352baa7bd8dc,
836c1ff792d1174f03b080381b25247dcf59ffc065325bbea4fae0616547cd54a47c0d437d33d70cb7b36
cf38bc8d22ca1e9ff3986ad0b3bd661a1271ec3e509)

Den receives key
```

5. B розшифровує обидва значення своїм секретним ключем

```
Decrypting...

Decrypted key:  21122019

Decrypted signature:
108f1e1875155d184585cc56d60cd199b8daccf1731b419f9f4531e268d220b6ad8c819067c964914f695
5c759e00275bdd884b8cda7970bf4e5258e5dd95e
```

6. B перевіряє підпис ключата пересвідчується, що ключ прийшов саме від абонента A

```
Checking signature

Message: 21122019

S^e mod n = 21122019

Signature verified
```

7. Абонент B успішно отримав ключ від абонента A

```
Key recieved

Den received key 21122019
```