# Homework 2

Encryption / decryption comparison

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## 1 Compile and run the algorithms

### 1.1 Source code content

The zip file named **symmetric-encryption.zip** contains the source code:

- **aes-cbc.c**: AES 128 CBC encryption / decryption
- **aria-cbc.c**: ARIA 128 CBC encryption / decryption
- **camellia-cbc.c**: Camellia 128 CBC encryption / decryption
- **aes-cbc.c**: AES 128 CBF encryption / decryption (I tried a different operation mode also)

and the files to encrypt / decrypt:

- **1k.txt**: 1 kB text file
- **10.txt**: 10 kB text file
- **large-binary.MP4**: ¿ 1MB binary file

### 1.2 Compille the code

I downloaded, compiled and installed the OpenSSL 3.3.2 libraries under the local directory of my Fedora Linux file system:

```
/home/fax/lib/openssl-3.3.2/
```

To compile my files I run the commands in any order:

```
gcc aes-cbc.c -o aes-cbc -I /home/fax/lib/openssl-3.3.2/include \
-L /home/fax/lib/openssl-3.3.2/lib64 -lcrypto
```

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```
gcc aria-cbc.c -o aria -I /home/fax/lib/openssl-3.3.2/include \
-L /home/fax/lib/openssl-3.3.2/lib64 -lcrypto

gcc camellia-cbc.c -o camellia -I /home/fax/lib/openssl-3.3.2/include \
-L /home/fax/lib/openssl-3.3.2/lib64 -lcrypto

gcc aes-cbf.c -o aes-cbf -I /home/fax/lib/openssl-3.3.2/include \
-L /home/fax/lib/openssl-3.3.2/lib64 -lcrypto
```

### 1.3 Encrypt / decrypt the test files

- run **./aes-cbc** to encrypt / decrypt the files using AES 128 CBC
- run **./aria-cbc** to encrypt / decrypt the files using Aria 128 CBC
- run **./camellia-cbc** to encrypt / decrypt the files using Camellia 128 CBC
- run **./aes-cbf** to encrypt / decrypt the files using AES 128 CBF

After running those commands more files are generated. In particular one file as a result of the decryption and one file as the result of the encryption for each original file and for each algorithm.

For instance *large-binary-ari.dat* is the result of the encryption using Aria 128 CBC of the original binary file *large-binary-ari.MP4*. While *large-binary-ari-dec.MP4* is the result of the decryption using Aria 128 CBC of the encrypted binary file *large-binary-ari.dat*.

In our implementation *large-binary-ari-dec.MP4* must be identical to the original one *large-binary-ari.dat*.

And this must be true for all the combinations of files / algorithms.

You can check the file names looking at the console output logs.

### 1.4 Console output for execution

Here is an execution. You can notice that both the secret keys and the initialization vectors are randomly generated, in particular using a random generation API of Open SSL.

```
fax@fedora:~/Documents/study-more/cyber/homeworks/h2/symmetric-encryption$ ./aria

The key : 27 C1 F8 E0 E8 BE 7D 16 75 6C 50 E0 66 3C 92 D3
The IV  : 82 58 8A 70 2B D9 92 17 7C 11 9F 4F 2F 84 1A BC
Aria CBC << encrypt >> 1k.txt -> 1k-ari.dat:  24 microseconds
Aria CBC << decript >> 1k-ari.dat -> 1k-ari-dec.txt:  15 microseconds
Aria CBC << encrypt >> 10k.txt -> 10k-ari.dat:  76 microseconds
Aria CBC << decript >> 10k-ari.dat -> 10k-ari-dec.txt:  60 microseconds
Aria CBC << encrypt >> large-binary.MP4 -> large-binary-ari.dat:  21248 microseconds
Aria CBC << decript >> large-binary-ari.dat -> large-binary-ari-dec.MP4:
18136 microseconds
```

```
fax@fedora:~/Documents/study-more/cyber/homeworks/h2/symmetric-encryption$ ./aes-cbc

The key : 10 48 8A A3 FB AB FA 75 D4 28 0C 7D 4B 24 D7 AC
The IV  : CB 5F 5F 92 C6 AE 9B 4A AD 32 B3 13 32 9C C2 7C
AES CBC << encrypt >> 1k.txt -> 1k-cbc.dat:  12 microseconds
AES CBC << decrypt >> 1k-cbc.dat -> 1k-cbc-dec.txt:  9 microseconds
AES CBC << encrypt >> 10k.txt -> 10k-cbc.dat:  59 microseconds
AES CBC << decrypt >> 10k-cbc.dat -> 10k-cbc-dec.txt:  90 microseconds
AES CBC << encrypt >> large-binary.MP4 -> large-binary-cbc.dat:  19761 microseconds
AES CBC << decrypt >> large-binary-cbc.dat -> large-binary-cbc-dec.MP4:
25073 microseconds

fax@fedora:~/Documents/study-more/cyber/homeworks/h2/symmetric-encryption$ ./camellia

The key : C3 A8 9D AB A4 C2 B2 E7 A9 DF 09 31 0D 6F 84 B2
The IV  : 09 21 C9 52 45 24 E3 7B 38 74 F6 95 F6 AD FB 17
Camellia CBC << encrypt >> 1k.txt -> 1k-cam.dat:  12 microseconds
Camellia CBC << decrypt >> 1k-cam.dat -> 1k-cam-dec.txt:  5 microseconds
Camellia CBC << encrypt >> 10k.txt -> 10k-cam.dat:  54 microseconds
Camellia CBC << decrypt >> 10k-cam.dat -> 10k-cam-dec.txt:  45 microseconds
Camellia CBC << encrypt >> large-binary.MP4 -> large-binary-cam.dat:
16318 microseconds
Camellia CBC << decrypt >> large-binary-cam.dat -> large-binary-cam-dec.MP4:
13364 microseconds

fax@fedora:~/Documents/study-more/cyber/homeworks/h2/symmetric-encryption$ ./aes-cbf

The key : 8E F5 78 EA 20 F0 B3 E8 DA 62 FE CF C6 D2 2E B5
The IV  : 40 22 E0 DF 01 06 04 63 B8 6D 06 E2 D0 89 9A D1
AES CFB 128 << encrypt >> 1k.txt -> 1k-aes.dat:  14 microseconds
AES CFB 128 << decrypt >> 1k-aes.dat -> 1k-aes-dec.txt:  7 microseconds
AES CFB 128 << encrypt >> 10k.txt -> 10k-aes.dat:  67 microseconds
AES CFB 128 << decrypt >> 10k-aes.dat -> 10k-aes-dec.txt:  68 microseconds
AES CFB 128 << encrypt >> large-binary.MP4 -> large-binary-aes.dat:
25146 microseconds
AES CFB 128 << decrypt >> large-binary-aes.dat -> large-binary-aes-dec.MP4:
24757 microseconds
```

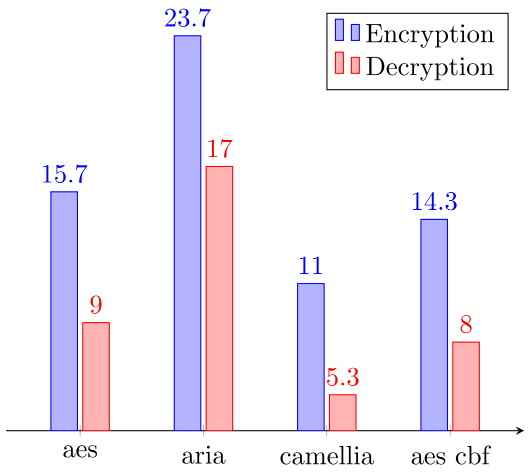
## 2 Collect the results

We have 6 values collected for each algorithms (that are the encryption and the decryption of each test file).

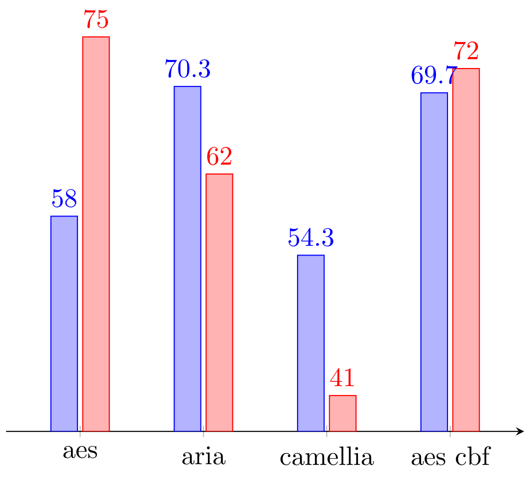
Averaging the result of three distinct executions, I got the following results:

| Microseconds | AES CBC | ARIA CBC | CAMELLIA CBC | AES CBF |
|---|---|---|---|---|
| 1K encrypt | 15.7 | 23.7 | 11 | 14.3 |
| 1K decrypt | 9 | 17 | 5.3 | 8 |
| 10K encrypt | 58 | 70.3 | 54.3 | 69.7 |
| 10K decrypt | 75 | 62 | 41 | 72 |
| 1M+ encrypt | 19000 | 21176 | 16079.7 | 22537.3 |
| 1M+ decrypt | 25095.3 | 18003.3 | 13170.3 | 22838.7 |

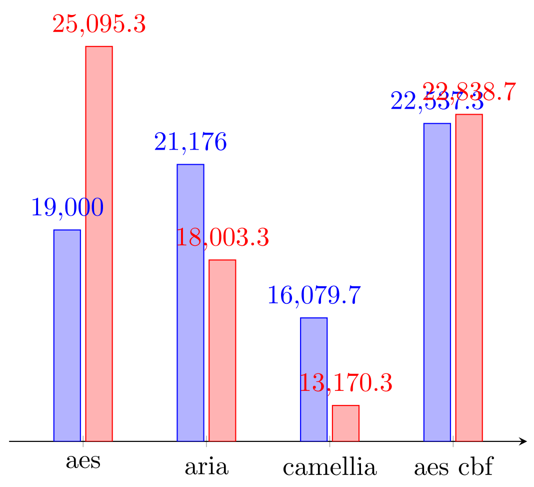
Encryption / decryption 1K text



Encryption / decryption 10K text



Encryption / decryption 10K text


aes
aria
camellia
aes cbf