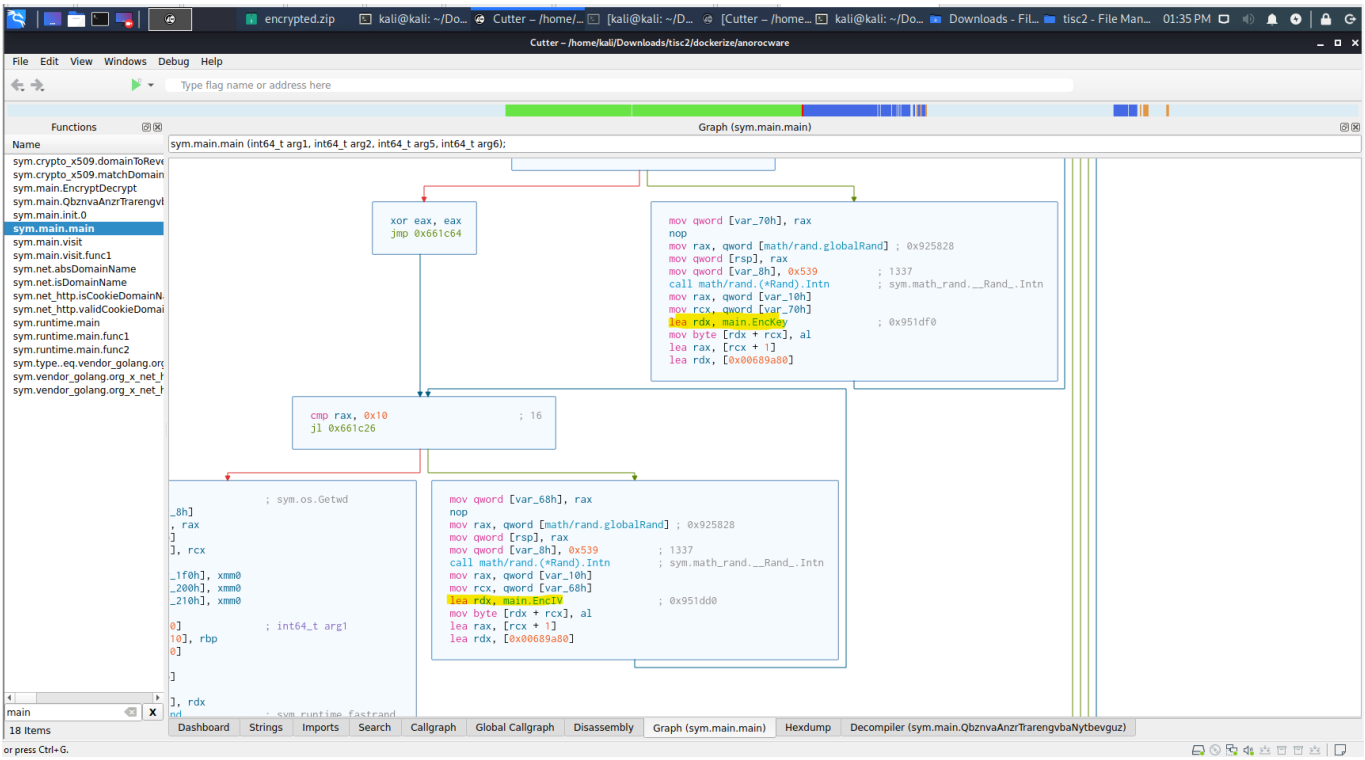
Stage 3

> This stage was a bit painful for me, as I tried many programming languages and websites (even 'learning' Golang) for AES-CTR, but it does not want to decrypt, so I decided to cheese it and inject the key and IV into the ransomware (as AES-CTR's encrypt and decrypt mode are invertible).

So for this stage, we were given the task to attempt to decrypt the files to see if it is recoverable. From the files given we can see that there is a file called `keydetails-enc.txt`, and showing the hex values of it yields nothing of interest as of now.

```
kali@kali:~/Downloads/tisc2$ xxd keydetails-enc.txt
00000000: 04ac a8af 91f9 7ef1 98ba 32c8 20e8 868d  ......~...2. ...
00000010: eb69 3f86 f763 d3a2 879a 84fa 8e7a f6f3  .i?..c.......z..
00000020: 9610 7701 b480 e453 ec69 b7e3 f72f 0252  ..w....S.i.../.R
00000030: 0f40 8a98 c163 db6c 70f9 902e ab87 c882  .@...c.lp.......
...
000001d0: 8455 5f44 12da 28d7 434b fa27 d6b4 cdf4  .U_D..(.CK.'....
000001e0: da50 889c 9285 c8ca 0e60 6398 bfb3 b348  .P.......`c....H
000001f0: 9475 2667 df01 a280 23b7 297d 3a16 978f  .u&g....#.)}:...
00000200: 4a97 4cf2 d040 88                        J.L..@.
```

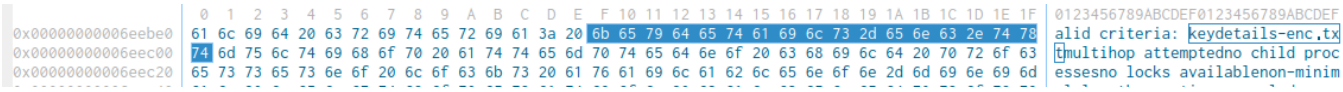
Looking back at Cutter, we can see in the graph that even though Stage 1's public key is being initialized, it is not being used in any way after that. However we can see that at the start of the program, the key and IV are generated then.



From that, we know that it is a randomly generated number from the operating system, and it does not seem like it is seeded in any way. A few block below we can see that the program writes to a file before reading

anything, which may indicate that it is creating a new file..?

Looking up a few instructions, there is a `lea rdx, [0x006eebef]` instruction. We can open it (right click > 0x006eebef (used here) > Hexdump) and see what it gives, and it shows the `keydetails-enc.txt` file! This shows that it is probably writing something important, and the instructions above must indicate the content and encoding.



The block above the write to file code possibly shows the encryption or encoding scheme they used. From this we can see, they are using Go's `big_nat` to perform an exponential function and converting it to bytes to store in a file.

```
mov qword [rsp], rax
call net/url.Values.Encode          ; sym.net_url.Values.Encode
lea rax, [var_b0h]
mov qword [rsp], rax
call runtime.stringtoslicebyte      ; sym.runtime.stringtoslicebyte
mov rax, qword [var_1e8h]
mov rcx, qword [var_1e0h]
mov rdx, qword [var_1d8h]
mov qword [rsp], rdx
mov qword [var_8h], rcx
mov qword [var_10h], rax
call math/big.nat.setBytes          ; sym.math_big.nat.setBytes
mov rax, qword [var_38h]
mov rcx, qword [var_40h]
mov rdx, qword [var_30h]
mov qword [var_1d8h], rdx
mov qword [var_1e0h], rax
mov qword [var_1e8h], rcx
mov byte [var_1d0h], 0
mov rax, qword [var_e8h]
mov rcx, qword [rax + 8]
mov byte [var_1b0h], 0
mov qword [var_1b8h], 0
xorps xmm0, xmm0
movups xmmword [var_1c0h], xmm0
lea rdx, [var_1b0h]
mov qword [rsp], rdx
mov qword [var_8h], rcx
call math/big.(*Int).SetInt64       ; sym.math_big.__Int_.SetInt64
mov rax, qword [var_e8h]
mov rax, qword [rax]
lea rcx, [var_1d0h]
mov qword [rsp], rcx
mov qword [var_8h], rcx
mov qword [var_18h], rax
call math/big.(*Int).Exp            ; sym.math_big.__Int_.Exp
mov rax, qword [var_20h]
mov qword [var_d0h], rax
nop
mov rcx, qword [rax + 0x10]
lea rdx, [0x00689c40]
mov qword [rsp], rdx
shl rcx, 3
mov qword [var_88h], rcx
mov qword [var_8h], rcx
mov qword [var_10h], rcx
call runtime.makeslice              ; sym.runtime.makeslice
mov rax, qword [var_18h]
mov qword [var_110h], rax
mov rcx, qword [var_d0h]
mov rdx, qword [rcx + 0x18]
mov rbx, qword [rcx + 0x10]
mov rcx, qword [rcx + 8]
mov qword [rsp], rcx
mov qword [var_8h], rbx
mov qword [var_10h], rdx
mov rcx, qword [var_88h]
mov qword [var_20h], rcx
mov qword [var_28h], rcx
call math/big.nat.bytes             ; sym.math_big.nat.bytes
mov rax, qword [var_30h]
mov rcx, qword [var_88h]
cmp rax, rcx
```

Since we cannot directly see what values they are trying to power with, therefore we will get the address of the instruction running the `call math/big.(*Int).Exp` function, and setting a breakpoint there to see the values in the register and stack.

```
pwndbg> b *0x006622fd
Breakpoint 1 at 0x6622fd: file /home/hjf98/Documents/CSPC2020Dev/goware/main.go,
line 269.
pwndbg> r
Starting program: /home/kali/Downloads/tisc2/anorocware
[Thread debugging using libthread_db enabled]
Using host libthread_db library "/lib/x86_64-linux-gnu/libthread_db.so.1".
...

Thread 7 "anorocware" hit Breakpoint 1, 0x00000000006622fd in main.main () at
/home/hjf98/Documents/CSPC2020Dev/goware/main.go:269
269     /home/hjf98/Documents/CSPC2020Dev/goware/main.go: No such file or
directory.
```

```
LEGEND: STACK | HEAP | CODE | DATA | RWX | RODATA
─────────────────────────────────────────────────────────────────────────────────
──────────────────[ REGISTERS
]──────────────────────────────────────────────────────────────────────────────
 RAX  0xc000238080 ◂— 0x0
 RBX  0xc0000fddb8 ◂— 0x0
 RCX  0xc0000fddd8 —▸ 0x414100 (runtime.mapaccess2_faststr+528) ◂— movzx  r8d,
byte ptr [rdx + rcx]
 RDX  0xc00025e0a0 ◂— 0x3
 RDI  0x8
 RSI  0x0
...
─────────────────────────────────────────────────────────────────────────────────
──────────────────[ DISASM
]──────────────────────────────────────────────────────────────────────────────
 ► 0x6622fd <main.main+2477>    call   math/big.(*Int).Exp <math/big.(*Int).Exp>
        rdi: 0x8
        rsi: 0x0
        rdx: 0xc00025e0a0 ◂— 0x3
        rcx: 0xc0000fddd8 —▸ 0x414100 (runtime.mapaccess2_faststr+528) ◂— movzx
r8d, byte ptr [rdx + rcx]
        r8: 0x6892c0 (type.*+151712) ◂— 0x8

   0x662302 <main.main+2482>    mov    rax, qword ptr [rsp + 0x20]
...
─────────────────────────────────────────────────────────────────────────────────
──────────────────[ STACK
]──────────────────────────────────────────────────────────────────────────────
00:0000│ rsp  0xc0000fdc08 —▸ 0xc0000fddd8 —▸ 0x414100
(runtime.mapaccess2_faststr+528) ◂— movzx  r8d, byte ptr [rdx + rcx]
... ↓
02:0010│      0xc0000fdc18 —▸ 0xc0000fddb8 ◂— 0x0
03:0018│      0xc0000fdc20 —▸ 0xc000238080 ◂— 0x0
04:0020│      0xc0000fdc28 ◂— 0xab
05:0028│      0xc0000fdc30 ◂— 0xb0
06:0030│      0xc0000fdc38 —▸ 0xc000284410 ◂—
'f27f3e1bdea433d808a4be710c6c24c0=dIenihcaM&302.39.87.101=PI&wUK28%4D%E6D%B5%EDC3%
6B%C7%81%DC%V=yeKcnE&7C%+C5%1B%_RNh4A%621%EF%FA%11%D3%8C%=VIcnE&gnajnaP+tikuB+gnop
maK=ytiC'
07:0038│      0xc0000fdc40 ◂— 0x16
─────────────────────────────────────────────────────────────────────────────────
──────────────────[ BACKTRACE
]──────────────────────────────────────────────────────────────────────────────
 ► f 0           6622fd main.main+2477
   f 1           43692a runtime.main+506
   f 2           463061 runtime.goexit+1
   f 3                0
─────────────────────────────────────────────────────────────────────────────────
─────────────────────────────────────────────────────────────────────────────────
```

```
──────────────────────────────────────────────────────────────────
pwndbg>
```

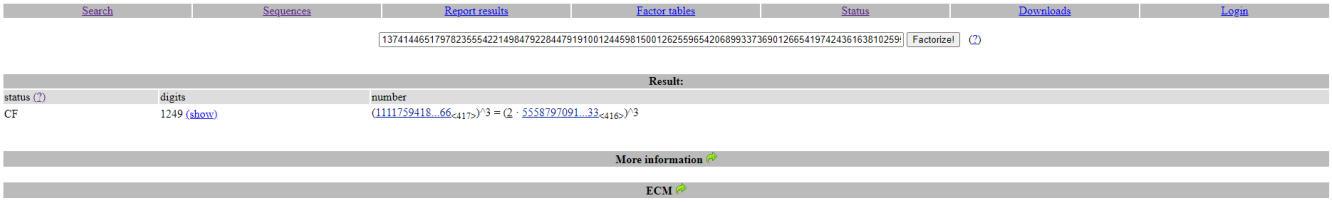
From the runtime, we can see a lot of interesting things, such as the reversed order for what looks like the EncKey and EncIV in the stack, so we can confirm they are using it to store in the file.

Before the function call, it looks like it is passing in the string data, as well as `0x3`, which *probably* means it is powering the string with 3.

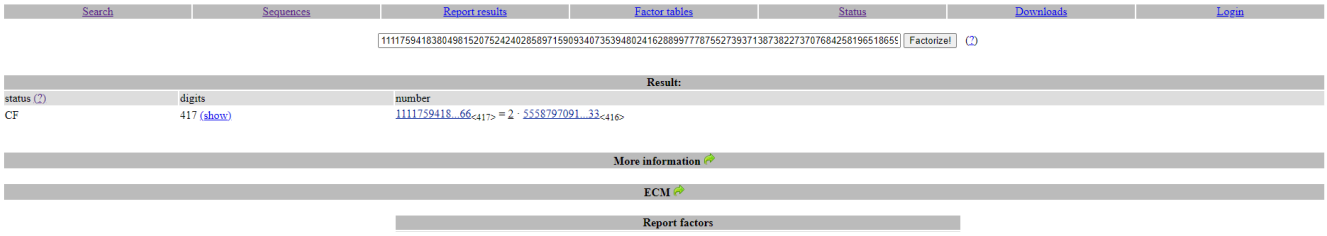
So we can try to retrieve the old key and IV by taking the zip file's `keydetails-enc.txt`, converting it to an integer, then using FactorDB, calculate the cube root of the number to see if we get anything useful.

```
kali@kali:~/Desktop$ xxd -p keydetails-enc.txt | tr -d '\n'
04aca8af91f97ef198ba32c820e8868deb693f86f763d3a2879a84fa8e7af6f396107701b480e453ec
69b7e3f72f02520f408a98c163db6c70f9902eab87c882b73c158e16be95dc4a9921fec3297586343b
250f6cf58f3512e37de84e2f3d12639bec4f88ed5e68226fad6c2e5dbdfe9b44350aaedc61015e8f28
cce50a69c67f919f0c5d2c2c9073bf4d25afb299e65acf703880949b32f5e442e77cf527f6a8a3881b
a1f94e79103abb9c1a1f55a4735488e05d0a41fd7feb3b7c130c2139dcc4301a55d87806e04f45ce21
0ecbc971bfaf7a2ff090f39709f4025f658f7729eb1cfbef40cfce7d469d1095f60144e2f312b6493c
e0cca3765189089425a04d035cdd6a80b131b231215141ae83f2a3410fc551ca30296be4ad3f7bf4cd
b1e09583f97d445150c037f88d7ca765174f8b202b6a5f513dd9f20b430bbbbfc2309293271faac024
b38cde3fc22555cd860ef79ae16697982e37650c933ced29879280f2301d7efcc4967dd77e668a65af
bc770d46669e67678f347c5d85ffe05218d8ebeec470ca1d74ae8956589db43999a1643a95b0a72acf
6ace052fdef8bcc63dc7ce67024866d4e7cb421965218614a41e0789c7239733e6f97c00f1db05bff3
e1283e3790a4a9ac2e6f1cfa5084555f4412da28d7434bfa27d6b4cdf4da50889c9285c8ca0e606398
bfb3b34894752667df01a28023b7297d3a16978f4a974cf2d04088kali@kali:~/Desktop$ python3
Python 3.8.5 (default, Aug  2 2020, 15:09:07)
[GCC 10.2.0] on linux
Type "help", "copyright", "credits" or "license" for more information.
>>>
0x04aca8af91f97ef198ba32c820e8868deb693f86f763d3a2879a84fa8e7af6f396107701b480e453
ec69b7e3f72f02520f408a98c163db6c70f9902eab87c882b73c158e16be95dc4a9921fec329758634
3b250f6cf58f3512e37de84e2f3d12639bec4f88ed5e68226fad6c2e5dbdfe9b44350aaedc61015e8f
28cce50a69c67f919f0c5d2c2c9073bf4d25afb299e65acf703880949b32f5e442e77cf527f6a8a388
1ba1f94e79103abb9c1a1f55a4735488e05d0a41fd7feb3b7c130c2139dcc4301a55d87806e04f45ce
210ecbc971bfaf7a2ff090f39709f4025f658f7729eb1cfbef40cfce7d469d1095f60144e2f312b649
3ce0cca3765189089425a04d035cdd6a80b131b231215141ae83f2a3410fc551ca30296be4ad3f7bf4
cdb1e09583f97d445150c037f88d7ca765174f8b202b6a5f513dd9f20b430bbbbfc2309293271faac0
24b38cde3fc22555cd860ef79ae16697982e37650c933ced29879280f2301d7efcc4967dd77e668a65
afbc770d46669e67678f347c5d85ffe05218d8ebeec470ca1d74ae8956589db43999a1643a95b0a72a
cf6ace052fdef8bcc63dc7ce67024866d4e7cb421965218614a41e0789c7239733e6f97c00f1db05bf
f3e1283e3790a4a9ac2e6f1cfa5084555f4412da28d7434bfa27d6b4cdf4da50889c9285c8ca0e6063
98bfb3b34894752667df01a28023b7297d3a16978f4a974cf2d04088
137414465179782355542214984792284479191001244598150012625596542068993373690126654l
974243616381025950364679398374316728402330774959686117657134395961891732783384793 4
874720673475771555213736062708551980681020252638021461007197865004090209811914072 6
336841407456666611212377728255167851950047805662285070646800187368694940534226332 1
764228482555517006736710577538518213595786501751544857009785374100038208336642946 2
130684064911870046401536233686313483015100950472223065001622158414653836518937941 1
457520047796108000617702852367565687168466554914877561628792731222655607103241269 5
525727172866089935132542092018799167118650626885629353996069832277929480812448480 6
```

```
926313862432923867255140674765426160610861749430636516969221417738025390984164999809238307031268920174203930580790463194319929943991521042157182388818058800337179233166246870250809441825599925983945723342465578243488865614951451393013921971076234223498051215985748427277238646126726611077110466973667242930123206629271349289544318429015861902947179057262039814433764654781029360836439378575563447470066901395840047616855882507989431292213552573703272166036116856322859467637896908436742931448986577038656777505698306780255930815512520212014484232164498219721992495520285101454935874406980960
```



Clicking the base value will give the full value:



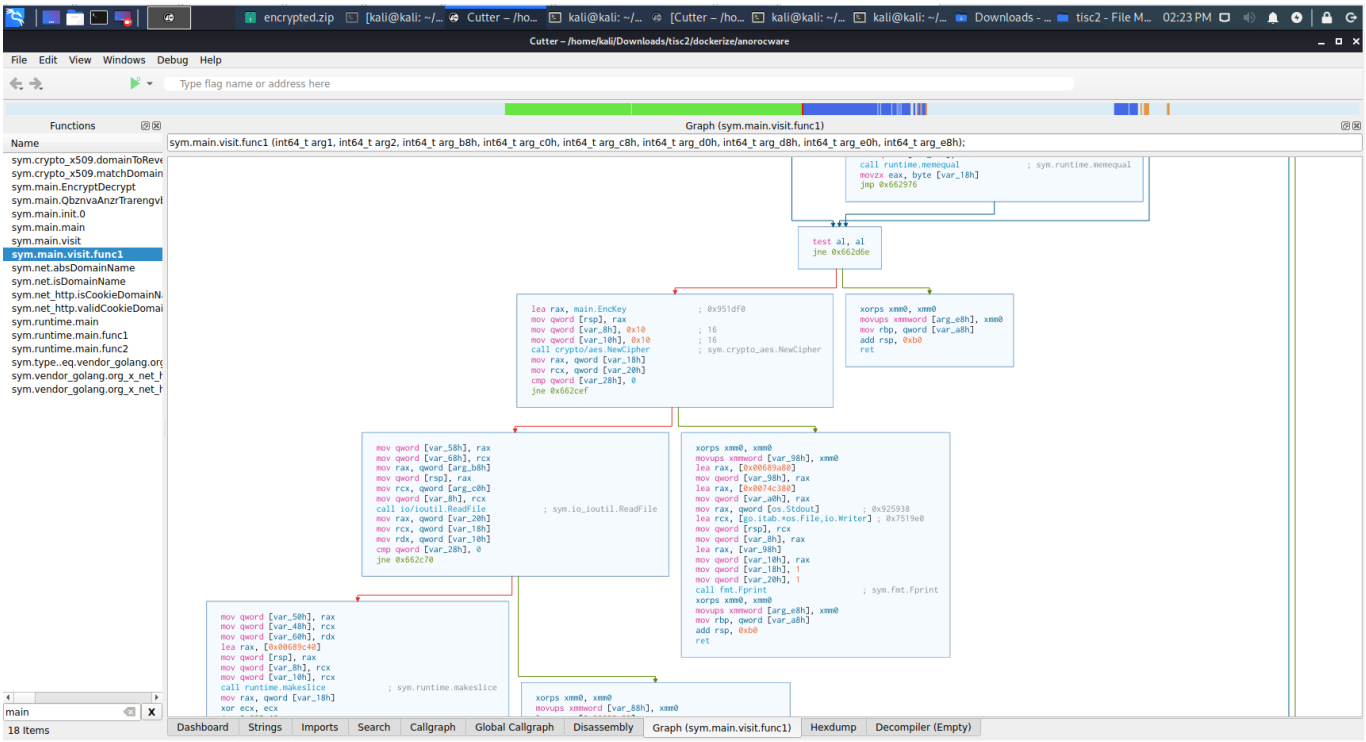

```
436974793d53696e6761706f726526456e6349563d25314325394625413425394225324325394
54e2541462530342539434125414525303225383625303325383126456e634b65793d2539397a
2531312531322537466a4425323225393325443225413825454225314432752530342649503d
3131322e3139392e3231302e313139264d616368696e6549643d3664386461373766353033633
961353536303037336331333132326139303362
```

Now we convert this integer back to string, and we got our EncKey and EncIV!

```
kali@kali:~/Desktop$ python3
Python 3.8.5 (default, Aug  2 2020, 15:09:07)
[GCC 10.2.0] on linux
Type "help", "copyright", "credits" or "license" for more information.
>>>
hex(11117594183804981520752424028589715909340735394802416288997778755273937138738227370768425819651865
5)
'0x436974793d53696e6761706f726526456e6349563d25314325394625413425394225324325394
54e2541462530342539434125414525303225383625303325383126456e634b65793d2539397a
2531312531322537466a4425323225393325443225413825454225314432752530342649503d
3131322e313139264d616368696e6549643d3664386461373766353033633961353536303037
3363313132326139303362'
>>> exit()
```

```
kali@kali:~/Desktop$ echo
"436974793d53696e6761706f726526456e6349563d2531432539462541342539422532432539454e2
5414625303425394341254145253032253836253033253831264 56e634b65793d2539397a253131253
1322537466a4425323225393325443225413825454225314432752530342649503d3131322e3139392
e3231302e313139264d616368696e6549643d3664386461373766353033633961353536303037336 33
1331332326139303362" | xxd -p -r
City=Singapore&EncIV=%1C%9F%A4%9B%2C%9EN%AF%04%9CA%AE%02%86%03%81&EncKey=%99z%11%1
2%7FjD%22%93%D2%A8%EB%1D2u%04&IP=112.199.210.119&MachineId=6d8da77f503c9a5560073c1
3122a903bkali@kali:~/Desktop$
```

We now have to find out what is the function used for encryption, and thanks to Cutter, we can see that there is a function called `visit` which we can view and it looks like the function for encrypting files! It also looks like they are using AES-CTR based on what they are initializing for their variables.




```
movzx eax, byte [rax + 1]
mov byte [0x00951de1], al
mov rax, qword [var_58h]
mov qword [rsp], rax
mov rax, qword [var_68h]
mov qword [var_8h], rax
lea rax, main.EncIVCur          ; 0x951de0
mov qword [var_10h], rax
mov qword [var_18h], 0x10       ; 16
mov qword [var_20h], 0x10       ; 16
call crypto/cipher.NewCTR       ; sym.crypto_cipher.NewCTR
mov rax, qword [var_28h]
mov rcx, qword [var_30h]
mov rax, qword [rax + 0x18]
mov qword [rsp], rcx
mov rcx, qword [var_70h]
mov qword [var_8h], rcx
```

Based on what I read online, AES-CTR mode is invertible, meaning if we were to dump the encrypted file in to encrypt, it will return us the decrypted file. So, what we can do is to change the `EncKey` and `EncIV` variables before the function executes them.

We first set up a new folder, where we remove all the .anoroc extensions.

```
kali@kali:~/Desktop/dockerize$ find -type f -name '*.anoroc' | while read f; do mv
"$f" "${f%.anoroc}"; done
kali@kali:~/Desktop/dockerize$ ls -al encrypted/
total 80
drwxr-xr-x 4 kali kali  4096 Sep  6 14:32 .
drwxr-xr-x 3 kali kali  4096 Aug  6 13:49 ..
-rw-r--r-- 1 kali kali 24576 Aug  6 13:49 clients.db
drwxr-xr-x 2 kali kali  4096 Sep  6 14:32 email
drwxr-xr-x 2 kali kali  4096 Sep  6 14:32 images
-rw-r--r-- 1 kali kali   519 Aug  6 13:49 keydetails-enc.txt
-rw-r--r-- 1 kali kali   984 Aug  6 13:49 ransomnote-anoroc.txt
-rw-r--r-- 1 kali kali 32768 Aug  6 13:49 secret_investments.db
```

We now run `gdb` and inject our newly found Key and IV (note that you have to swap endian-ness of both of them).

To swap endian-ness, we can use a helpful online tool called CyberChef. The link for this instance is here:

- IV: https://gchq.github.io/CyberChef/#recipe=URL_Decode()Swap_endianness('Raw',4,true)To_Hex('Space',0)&input=JTFDJTlGJUE0JTlCJTJDJTlFTiVBRiUwNCU5Q0ElQUUlMDIlODYlMDMlODE
- Key: https://gchq.github.io/CyberChef/#recipe=URL_Decode()Swap_endianness('Raw',4,true)To_Hex('Space',0)&input=JTk5eiUxMSUxMiU3RmpEJTIyJTkzJUQyJUE4JUVCJTFEMnUlMDQ

```
kali@kali:~/Desktop/dockerize$ gdb anorocware
GNU gdb (Debian 9.2-1) 9.2
Copyright (C) 2020 Free Software Foundation, Inc.
...

pwndbg> b *0x00662423
Breakpoint 1 at 0x662423: file /home/hjf98/Documents/CSPC2020Dev/goware/main.go,
line 295.
pwndbg> r
Starting program: /home/kali/Desktop/dockerize/anorocware
...

Thread 6 "anorocware" hit Breakpoint 1, main.main () at
/home/hjf98/Documents/CSPC2020Dev/goware/main.go:295
...
pwndbg> x/16x 0x951dd0
0x951dd0 <main.EncIV>:  0x8a22de90      0x94d3d593      0x112aad3e      0xbd740da9
0x951de0 <main.EncIVCur>:       0x00000000      0x00000000      0x00000000
0x00000000
0x951df0 <main.EncKey>: 0x102f5c25      0xfd8fcf59      0xbbe232e8      0xc74ebdbf
0x951e00:       0x00000000      0x00000000      0x00000000      0x00000000
pwndbg> set *0x951dd0=0x9ba49f1c
...
pwndbg> set *0x951dd4=0xaf4e9e2c
...
```

```
pwndbg> set *0x951dd8=0xae419c04
...
pwndbg> set *0x951ddc=0x81038602
...
pwndbg> set *0x951df0=0x12117a99
...
pwndbg> set *0x951df4=0x22446a7f
...
pwndbg> set *0x951df8=0xeba8d293
...
pwndbg> set *0x951dfc=0x0475321d
...
pwndbg> x/16x 0x951dd0
0x951dd0 <main.EncIV>:  0x9ba49f1c      0xaf4e9e2c      0xae419c04      0x81038602
0x951de0 <main.EncIVCur>:       0x00000000      0x00000000      0x00000000
0x00000000
0x951df0 <main.EncKey>: 0x12117a99      0x22446a7f      0xeba8d293      0x0475321d
0x951e00:       0x00000000      0x00000000      0x00000000      0x00000000
pwndbg> c
Continuing.
[Thread 0x7fffca7fc700 (LWP 5023) exited]
[Thread 0x7fffcaffd700 (LWP 5022) exited]
[Thread 0x7fffcbfff700 (LWP 5020) exited]
[Thread 0x7fffd0947700 (LWP 5019) exited]
[Thread 0x7fffd1148700 (LWP 5018) exited]
[Thread 0x7ffff7dca740 (LWP 5014) exited]
[Inferior 1 (process 5014) exited normally]
```

We can now remove all the extensions again, and check our file types to see that they are decrypted! As the flag is stored in a db, we should strings them.

```
kali@kali:~/Desktop/dockerize$ ls
anorocware  Dockerfile  Dockerfile.anoroc  encrypted  keydetails-enc.txt
ransomnote-anoroc.txt
kali@kali:~/Desktop/dockerize$ find -type f -name '*.anoroc' | while read f; do mv
"$f" "${f%.anoroc}"; done
kali@kali:~/Desktop/dockerize$ cd encrypted/
kali@kali:~/Desktop/dockerize/encrypted$ file
clients.db             images/                ransomnote-anoroc.txt
email/                 keydetails-enc.txt     secret_investments.db
kali@kali:~/Desktop/dockerize/encrypted$ file clients.db
clients.db: SQLite 3.x database, last written using SQLite version 3031000
kali@kali:~/Desktop/dockerize/encrypted$ file secret_investments.db
secret_investments.db: SQLite 3.x database, last written using SQLite version
3031000
kali@kali:~/Desktop/dockerize/encrypted$ strings *.db | grep TISC20
mTSIC20TISC20{u_decrypted_d4_fil3s_w0w_82161874619846}
kali@kali:~/Desktop/dockerize/encrypted$
```

There we go, the flag is `TISC20{u_decrypted_d4_fil3s_w0w_82161874619846}`.