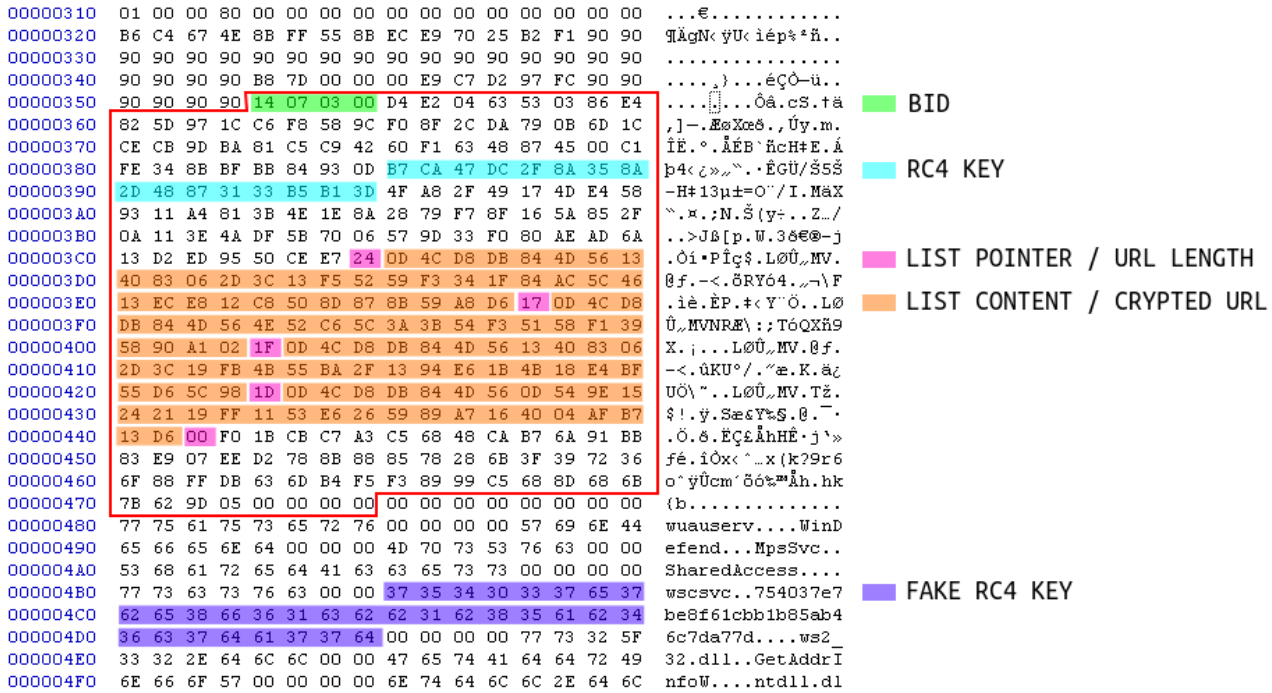
Knowledge Fragment: Bruteforcing Andromeda Configuration Buffers

byte-atlas.blogspot.ch/2015/04/kf-andromeda-bruteforcing.html

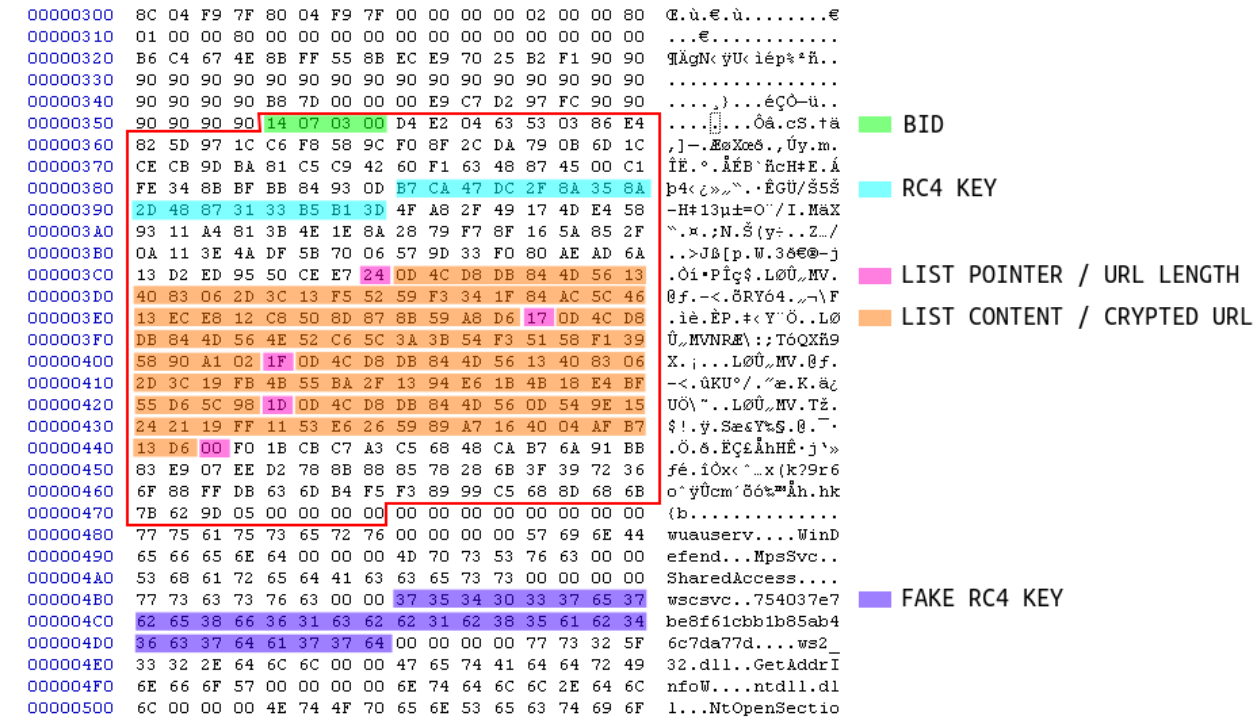


This blog post details how the more recent versions of Andromeda store their C&C URLs and RC4 key and how this information can be bruteforced from a memory dump.

Storage Format

The Andromeda configuration always starts with the value that is transferred as "bid" to the C&C server.
It is 4 bytes long and most likely resembles a builder / botnet ID. In some binaries I had a look at, this was likely a Y-M-D binary date as in the example shown below: 14-07-03.
After an arbitrary number of random bytes concatenated to the "bid", the binary RC4 key of length 16 bytes follows.
This key is both used to decrypt the configuration as well as to encrypt the C&C traffic.
Note that this key is stored in reversed order to decrypt the configuration buffer.
Next, more arbitrary random bytes are added, and then a linked list of encrypted C&C URLs follows.
The first byte of each list entry is the offset to the next list item; a zero byte pointer indicates the end of the list.
Each list entry is simply encrypted with the reversed RC4 key as described previously,

resulting in the crypted C&C entries having identical substrings at the start, the crypted equivalent of "http" => "\x0D\x4C\xD8\xDB".



Andromeda config buffer and fake RC4 key

Concealment of the configuration on bot initialization

During its initialization, the Andromeda bot parses this configuration buffer and stores its parts on the heap. Each data blob is prefixed with an indicator (crc32 over part of host processes' header, or 0x706e6800, xor bot_id), allowing the malware to identify its fragments on the heap in a similar way to the technique known as egg hunting.

```
parseConfig     proc near               ; CODE XREF: sub_7FF93428+91↓p
                                        ; DATA XREF: destroyParseConfig+5↓o ...

var_24          = dword ptr -24h
var_20          = dword ptr -20h
arg_0           = dword ptr  8

                push    ebp
                mov     ebp, esp
                sub     esp, 24h
                push    21h
                call    allocateMemory
                mov     ds:rc4key_offset, eax
                test    eax, eax
                jz      locret_7FF90F5D
                mov     eax, [ebp+arg_0]
                and     [ebp+var_20], 0
                push    esi
                xor     eax, 443BB35Dh
                push    edi
                xor     edi, edi
                mov     [ebp+var_24], eax
                xor     esi, esi

loc_7FF90EBF:                           ; CODE XREF: parseConfig+59↓j
                push    dword ptr ds:rc4key[esi]
                call    j_ntohl
                push    eax
                lea     eax, [ebp+var_24]
                push    eax
                mov     eax, ds:rc4key_offset
                add     eax, edi
                push    eax
                call    ds:wsprintfA
                add     esi, 4
                add     esp, 0Ch
                add     edi, 8
                cmp     esi, 10h
                jb      short loc_7FF90EBF
                mov     eax, ds:rc4key_offset
                xor     ecx, ecx
                add     eax, 1Fh

loc_7FF90EF5:                           ; CODE XREF: parseConfig+70↓j
                mov     dl, [eax]
                mov     byte ptr [ebp+ecx+var_24], dl
                inc     ecx
                dec     eax
                cmp     ecx, 20h
                jb      short loc_7FF90EF5
                mov     al, ds:cnc_urls
                and     [ebp+arg_0], 0
                mov     esi, offset cnc_urls
                test    al, al
                jz      short loc_7FF90F5B
                push    ebx

loc_7FF90F15:                           ; CODE XREF: parseConfig+C8↓j
                movzx   edi, al
                lea     eax, [edi+5]
                push    eax
                call    allocateMemory
                mov     ecx, [ebp+arg_0]
                or      ecx, 706E6800h
                xor     ecx, ds:dwBotId
                lea     ebx, [eax+4]
                push    ebx
                mov     [eax], ecx
                push    edi
                lea     eax, [esi+1]
                push    eax
                call    memcpy
                push    edi
                push    ebx
                push    20h
                lea     eax, [ebp+var_24]
                push    eax
                call    rc4crypt
                inc     [ebp+arg_0]
                lea     esi, [esi+edi+1]
                mov     al, [esi]
                test    al, al
                jnz     short loc_7FF90F15
                pop     ebx

loc_7FF90F5B:                           ; CODE XREF: parseConfig+82↑j
                pop     edi
                pop     esi

locret_7FF90F5D:                        ; CODE XREF: parseConfig+14↑j
                leave
                retn    4
parseConfig     endp
```

function used to handle the config and store rc4_key + C&C URLs on the heap

Afterwards, as a means of anti-analysis, the parsing routine is overwritten with a static 4 bytes (to kill the function prologue) and another function of the bot (in this case the function responsible for settings up hooking) in order to destroy the pointers to the RC4 key and C&C list.

```
destroyParseConfig proc near            ; CODE XREF: sub_7FF93428+96↓p
                                        ; DATA XREF: destroyParseConfig+24↓w
                push    ebp
                mov     ebp, esp
                push    esi
                push    edi
                lea     edi, parseConfig
                lea     esi, installHooks
                mov     ecx, offset loc_7FF90F79
                sub     ecx, edi

loc_7FF90F79:                           ; DATA XREF: destroyParseConfig+11↑o
                rep movsb
                mov     dword ptr ds:parseConfig, 0CC0004C2h
                mov     dword ptr ds:destroyParseConfig, 0CC0004C2h
                pop     edi
                pop     esi
                pop     ebp
                retn
destroyParseConfig endp
```

```
installHooks    proc near               ; CODE XREF: checkForRights+211↑p
                                        ; checkForRights+230↑p ...

arg_0           = dword ptr  8
arg_4           = dword ptr  0Ch
arg_8           = dword ptr  10h

                push    ebp
                mov     ebp, esp
                push    esi
                mov     esi, [ebp+arg_0]
                mov     al, [esi]
                push    edi
                xor     edi, edi
                cmp     al, 0E9h
                jnz     short loc_7FF91B79
                mov     eax, [esi+1]
                lea     eax, [eax+esi+5]

loc_7FF91B6B:                           ; CODE XREF: installHooks+3A↓j
                push    [ebp+arg_8]
                push    [ebp+arg_4]
                push    eax
                call    installHooks
                jmp     short loc_7FF91BEF
; ---------------------------------------------------------------------------

loc_7FF91B79:                           ; CODE XREF: installHooks+E↑j
                cmp     al, 0EBh
                jnz     short loc_7FF91B90
                movzx   eax, byte ptr [esi+1]
                test    al, al
                jns     short loc_7FF91B8A
                or      eax, 0FFFFFF00h

loc_7FF91B8A:                           ; CODE XREF: installHooks+2F↑j
                lea     eax, [eax+esi+2]
                jmp     short loc_7FF91B6B
; ---------------------------------------------------------------------------

loc_7FF91B90:                           ; CODE XREF: installHooks+27↑j
                mov     eax, esi

loc_7FF91B92:                           ; CODE XREF: installHooks+4C↓j
```

```
; ---------------------------------------------------------------------------
destroyedParseConfig dd 0CC0004C2h      ; CODE XREF: seg000:7FF90EAE↓p
                                        ; sub_7FF93428+91↓p
                                        ; DATA XREF: ...
; ---------------------------------------------------------------------------
                mov     esi, [ebp+8]
                mov     al, [esi]
                push    edi
                xor     edi, edi
                cmp     al, 0E9h
                jnz     short loc_7FF90EB5
                mov     eax, [esi+1]
                lea     eax, [eax+esi+5]

loc_7FF90EA7:                           ; CODE XREF: seg000:7FF90ECA↓j
                push    dword ptr [ebp+10h]
                push    dword ptr [ebp+0Ch]
                push    eax
                call    near ptr destroyedParseConfig
                jmp     short loc_7FF90F2B
; ---------------------------------------------------------------------------

loc_7FF90EB5:                           ; CODE XREF: seg000:7FF90E9E↑j
                cmp     al, 0EBh
                jnz     short loc_7FF90ECC
                movzx   eax, byte ptr [esi+1]
                test    al, al
                jns     short loc_7FF90EC6
                or      eax, 0FFFFFF00h

loc_7FF90EC6:                           ; CODE XREF: seg000:7FF90EBF↑j
                lea     eax, [eax+esi+2]
                jmp     short loc_7FF90EA7
; ---------------------------------------------------------------------------

loc_7FF90ECC:                           ; CODE XREF: seg000:7FF90EB7↑j
                mov     eax, esi

loc_7FF90ECE:                           ; CODE XREF: seg000:7FF90EDC↓j
```

top: function to destroy the parseConfig by overwriting with installHooks(), left: installHooks() right: resulting parseConfig

Extraction of RC4 key and C&C URLs

Although the exact offsets of RC4 key and C&C URL list are not available when examining a finally initialized Andromeda memory image in the injected process, it is possible to recover this information through guessing.

Finding the "bid"

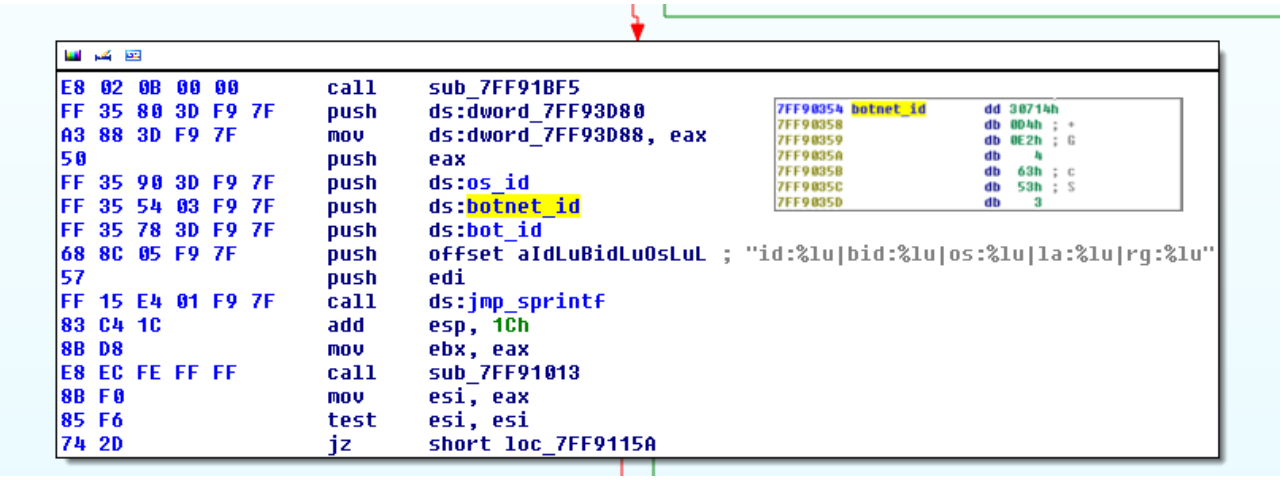
Characteristic for all encountered versions of Andromeda is a format string similar to the following:

id:%lu|bid:%lu|os:%lu|la:%lu|rg:%lu

or more recently:

{"id":%lu,"bid":%lu,"os":%lu,"la":%lu,"rg":%lu}

As its fields are likely filled in with a *sprintf* function, we can identify the offset of the "bid" by statically examining parameters passed to said string format API call (this can e.g. be achieved with a carefully crafted regex).



reference to the botnet/builder id "bid" with a characteristic sequence of instructions

Treating the "bid" as start for the potential configuration buffer, we can assume its end by searching for a zero dword value starting at the offset of the "bid".
For the tested memory dumps, the resulting potential configuration buffer had a length of around 300 bytes.

Identifying crypted C&C URL candidates

As described above, the C&C URLs are stored as a linked list.
Randomly assuming that a server address will be somewhere between 0x8 and 0x30 characters long, we can extract all byte sequences from the potential configuration buffer that match this property (start bytes highlighted):

```
0000  14 07 03 00 d4 e2 04 63 53 03 86 e4 82 5d 97 1c   .......cS....]..
0010  c6 f8 58 9c f0 8f 2c da 79 0b 6d 1c ce cb 9d ba   ..X...,.y.m.....
0020  81 c5 c9 42 60 f1 63 48 87 45 00 c1 fe 34 8b bf   ...B`.cH.E...4..
0030  bb 84 93 0d b7 ca 47 dc 2f 8a 35 8a 2d 48 87 31   ......G./.5.-H.1
0040  33 b5 b1 3d 4f a8 2f 49 17 4d e4 58 93 11 a4 81   3..=O./I.M.X....
0050  3b 4e 1e 8a 28 79 f7 8f 16 5a 85 2f 0a 11 3e 4a   ;N..(y...Z./..>J
0060  df 5b 70 06 57 9d 33 f0 80 ae ad 6a 13 d2 ed 95   .[p.W.3....j....
0070  50 ce e7 24 0d 4c d8 db 84 4d 56 13 40 83 06 2d   P..$.L...MV.@..-
0080  3c 13 f5 52 59 f3 34 1f 84 ac 5c 46 13 ec e8 12   <..RY.4....F....
0090  c8 50 8d 87 8b 59 a8 d6 17 0d 4c d8 db 84 4d 56   .P...Y....L...MV
00a0  4e 52 c6 5c 3a 3b 54 f3 51 58 f1 39 58 90 a1 02   NR..:;T.QX.9X...
00b0  1f 0d 4c d8 db 84 4d 56 13 40 83 06 2d 3c 19 fb   ..L...MV.@..-<..
00c0  4b 55 ba 2f 13 94 e6 1b 4b 18 e4 bf 55 d6 5c 98   KU./....K...U...
00d0  1d 0d 4c d8 db 84 4d 56 0d 54 9e 15 24 21 19 ff   ..L...MV.T..$!..
00e0  11 53 e6 26 59 89 a7 16 40 04 af b7 13 d6 00 f0   .S.&Y...@.......
```

00f0 1b cb c7 a3 c5 68 48 ca b7 6a 91 bb 83 e9 07 ee   .....hH..j.....
0100 d2 78 8b 88 85 78 28 6b 3f 39 72 36 6f 88 ff db   .x...x(k?9r6o...
0110 63 6d b4 f5 f3 89 99 c5 68 8d 68 6b 7b 62 9d 05   cm......h.hk{b..

resulting in the following candidate sequences (offset, length, start bytes):

offset: 0x000, 14->070300...
offset: 0x00f, 1c->c6f858...
offset: 0x016, 2c->da790b...
offset: 0x019, 0b->6d1cce...
offset: 0x01b, 1c->cecb9d...
offset: 0x033, 0d->b7ca47...
offset: 0x038, 2f->8a358a...
offset: 0x03c, 2d->488731...
offset: 0x046, 2f->49174d...
offset: 0x048, 17->4de458...
offset: 0x04d, 11->a4813b...
offset: 0x052, 1e->8a2879...
offset: 0x054, 28->79f78f...
offset: 0x058, 16->5a852f...
offset: 0x05b, 2f->0a113e...
offset: 0x05c, 0a->113e4a...
offset: 0x05d, 11->3e4adf...
offset: 0x06c, 13->d2ed95...
offset: 0x073, 24->0d4cd8...
offset: 0x074, 0d->4cd8db...
offset: 0x07b, 13->408306...
offset: 0x07f, 2d->3c13f5...
offset: 0x081, 13->f55259...
offset: 0x087, 1f->84ac5c...
offset: 0x08c, 13->ece812...
offset: 0x08f, 12->c8508d...
offset: 0x098, 17->0d4cd8...
offset: 0x099, 0d->4cd8db...
offset: 0x0b0, 1f->0d4cd8...
offset: 0x0b1, 0d->4cd8db...
offset: 0x0b8, 13->408306...
offset: 0x0bc, 2d->3c19fb...
offset: 0x0be, 19->fb4b55...
offset: 0x0c3, 2f->1394e6...
offset: 0x0c4, 13->94e61b...
offset: 0x0c7, 1b->4b18e4...
offset: 0x0c9, 18->e4bf55...

offset: 0x0d0, 1d->0d4cd8...
offset: 0x0d1, 0d->4cd8db...
offset: 0x0d8, 0d->549e15...
offset: 0x0db, 15->242119...
offset: 0x0dc, 24->2119ff...
offset: 0x0dd, 21->19ff11...
offset: 0x0de, 19->ff1153...
offset: 0x0e0, 11->53e626...
offset: 0x0e3, 26->5989a7...
offset: 0x0e7, 16->4004af...
offset: 0x0ec, 13->d600f0...
offset: 0x0f0, 1b->cbc7a3...
offset: 0x106, 28->6b3f39...

Identifying the RC4 key

Next, we can try to decrypt these URL candidates by using all possible RC4 keys from the potential configuration buffer.
For this, we take every consecutive 16 bytes, hex encode them, reverse their order, and perform RC4 against all C&C URL candidates.

Example: candidate sequence at offset 0xd1, length: 0x1d bytes:

```
00d0  1d 0d 4c d8 db 84 4d 56 0d 54 9e 15 24 21 19 ff   ..L...MV.T..$!..
00e0  11 53 e6 26 59 89 a7 16 40 04 af b7 13 d6 00 f0   .S.&Y...@.......
```

bruteforce decryption attempts:

```
rc4(candidate, "c179d5284e68303536402e4d00307041") -> 60a1619e84209c
rc4(candidate, "6cc179d5284e68303536402e4d003070") -> d378675057f8f2
rc4(candidate, "8f6cc179d5284e68303536402e4d0030") -> 84ff7a9c4e2168
rc4(candidate, "858f6cc179d5284e68303536402e4d00") -> 3b5dd0750955f6
[... 44 more attempts ...]
rc4(candidate, "33137884d2a853a8f2cd74ac7bd03948") -> 7cea19689c5d40
rc4(candidate, "5b33137884d2a853a8f2cd74ac7bd039") -> 38ca7a0068f32e
rc4(candidate, "1b5b33137884d2a853a8f2cd74ac7bd0") -> 6429d8151a51c2
rc4(candidate, "d31b5b33137884d2a853a8f2cd74ac7b") -> 687474703a2f2f
```

finally we hit a result of 687474703a2f2f which translates to "http://" and the whole URL decrypts to "hxxp://sunglobe.org/index.php" (defanged).

As soon as we decrypt the first sequence starting with "http" we have likely identified the correct RC4 key and can proceed to decrypt all other candidates to complete the list of C&C URLs.

RC4 key used for config: d31b5b33137884d2a853a8f2cd74ac7b
Actual traffic RC4 key: b7ca47dc2f8a358a2d48873133b5b13d

All resolving candidates:

0d4cd8db844d560d549e15242119ff1153e6265989a7164004afb713d6
-> hxxp://sunglobe.org/index.php

0d4cd8db844d56134083062d3c19fb4b55ba2f1394e61b4b18e4bf55d65c98
-> hxxp://masterbati.net/index.php

0d4cd8db844d564e52c65c3a3b54f35158f1395890a102
-> hxxp://0s6.ru/index.php

0d4cd8db844d56134083062d3c13f55259f3341f84ac5c4613ece812c8508d878b59a8d6
-> hxxp://masterhomeguide.com/index.php

Conclusion

It's obvious that the above described method can be optimized here and there. But since it executes in less than a second on a given memdump and gave me good results on a collection of Andromeda dumps, I didn't bother to improve it further.

sample used:
  md5: a17247808c176c81c3ea66860374d705
  sha256: ce59dbe27957e69d6ac579080d62966b69be72743143e15dbb587400efe6ce77

Repository with defanged memdump + extraction code