Clamav funcation call flow(AC scan)

ac scan with regex signature

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The call flow

When Clamav doing specific file scan (clamscan.c), there are following procedures:

- Initialize data structures
- Set engine parameters
- Load signatures
- Scan

Data structures

See *flow_normal_sgin_bm_scan.pdf*

Test case

test.txt

```
STARToooTESTkkkMYOtestTEST
```

ndb test

create ndb signature for test.txt

format

MalwareName:TargetType:Offset:HexSignature

where TargetType is one of the following numbers specifying the type of the target file:

0: Any file

1: Portable Executable

2: OLE2 component (eg: VBA script)

3: HTML (normalized)

4: Mail File

5: Graphics

6: ELF

7: ASCII text file (normalized)

And Offset is an asterisk or a decimal number n possibly combined with a special modifier:

- * = any
- n = absolute offset
- EOF-n = end of file minus n bytes

Signatures for PE and ELF files additionally support:

- EP+n = entry point plus n bytes (EP+0 for EP)
- EP-n = entry point minus n bytes
- Sx+n = start of section x's (counted from 0) data plus n bytes
- Sx-n = start of section x's data minus n bytes
- SL+n = start of last section plus n bytes
- SL-n = start of last section minus n bytes

All the above offsets except * can be turned into **floating offsets** and represented as Offset,MaxShift where MaxShift is an unsigned integer. A floating offset will match every offset between Offset and Offset+MaxShift, eg. 10,5 will match all offsets from 10 to 15 and EP+n,y will match all offsets from EP+n to EP+n+y. Versions of ClamAV older than 0.91 will silently ignore the MaxShift extension and only use Offset.

HexSignature

Wildcards

ClamAV supports the following extensions inside hex signatures:

- ??

Match any byte.

• `a?`

Match a high nibble (the four high bits). **IMPORTANT NOTE:** The nibble matching is only available in libclamav with the functionality level 17 and higher therefore please only use it with .ndb signatures followed by ":17" (MinEngineFunctionalityLevel, see 2.3.4).

• `?a`

Match a low nibble (the four low bits).

• `*`

Match any number of bytes.

• `{n}`

Match n bytes.

• `{-n}`

Match n or less bytes.

• `{n-}`

Match n or more bytes.

• `(aa|bb|cc|..)`

Match aa or bb or cc..

• `HEXSIG[x-y]aa` or `aa[x-y]HEXSIG`

Match aa anchored to a hex-signature, see `https://wwws.clamav.net/bugzilla/show_bug.cgi?id=776` for a discussion and examples.

The range signatures `*` and `{}` virtually separate a hex-signature into two parts, eg. `aabbcc*bbaacc` is treated as two sub-signatures `aabbcc` and `bbaacc` with any number of bytes between them. It's a requirement that each sub-signature includes a block of two static characters somewhere in its body.

```
user@ubuntu:~/clamav$ sigtool --hex-dump
ooo*kkk
6f6f6f2a6b6b6b
```

File test.ndb

```
test_ndb_regex:0:3,5:6f6f6f{4}6b6b6b
```

```
sudo cp test.ndb /var/lib/clamav/test.ndb
```

Above is a regex based signature with offset info, so it will be loaded into ac pattern structure and will be used in ac scan mode.

The virus record will match start offset between 3 and 5 with pattern as "ooo{4}kkk"(i.e.: any file with sub string "ooo'any 4 bytes'kkk" with the sub string's start at any position between absolute offset 3 and 5 will be identified as virus file)

run

```
LibClamAV Warning: **************************************************
LibClamAV Warning: ***  The virus database is older than 7 days!  ***
LibClamAV Warning: ***   Please update it as soon as possible.    ***
LibClamAV Warning: **************************************************
LibClamAV info: DEBUG: scan in bm_offmode=0 mode
LibClamAV info: DEBUG: ac scan
test.txt: test_ndb_regex.UNOFFICIAL FOUND
LibClamAV info: DEBUG: scan in bm_offmode=0 mode
LibClamAV info: DEBUG: ac scan
test1.txt: test_ndb_regex.UNOFFICIAL FOUND

----------- SCAN SUMMARY -----------
Known viruses: 1329150
Engine version: devel-a6558b5
Scanned directories: 0
Scanned files: 2
Infected files: 2
Data scanned: 0.00 MB
Data read: 0.00 MB (ratio 0.00:1)
Time: 5.562 sec (0 m 5 s)
user@ubuntu:~/clamav$
```

Engine initialiazation and load signatures

```
scanmanager
 cl_load
  cli_load
   cli_loadndb
    cli_initroots
     cli_ac_init
      filter_init
     cli_bm_init
    cli_parse_add
     // change from "6f6f6f{4}6b6b6b" to "6f6f6f????????6b6b6b"
     if((wild = strchr(hexsig, '{')))
      if(sscanf(wild, "%c%u%c", &l, &range, &r) == 3 && l == '{' && r == '}' && range > 0 &&
range < 128)
        hexcpy = cli_calloc(hexlen + 2 * range, sizeof(char));
        strncpy(hexcpy, hexsig, wild - hexsig);
        strcat(hexcpy, "??");
        wild = strchr(wild, '}')
        strcat(hexcpy, ++wild);
        //call again
        cli_parse_add(root, virname, hexcpy, rtype, type, offset, target, lsigid, options);
          if(root->ac_only || type || lsigid || strpbrk(hexsig, "?([") || (root->bm_offmode &&
(!strcmp(offset, "*") || strchr(offset, ','))) || strstr(offset, "VI") || strchr(offset, '$'))
     cli_ac_addsig
     cli_ac_addpatt
```

cli_ac_addpatt //*
filter_add_acpatt
cli_caloff //*

the loading:

this signature “test_ndb_regex:0:3,5:6f6f6f{4}6b6b6b” has regular expression involved, so should be loaded into AC scan sturcture.

Meanwhile, if the signature doesn’t specific a target type, it should be loaded to root[0](generic).

During the db loading process, filter_add_acpatt would be called to calculate prefiltering(using shift or FSM) data of the signatures which will speed up following bm scan a little bit.

load for ndb

```
#define NDB_TOKENS 6 // NDB have 6 fields
cli_loadndb
    cli_initroots
        for(i = 0; i < CLI_MTARGETS; i++) {
            if(cli_mtargets[i].ac_only || engine->ac_only) root->ac_only = 1;
            cli_ac_init // allocate memory for
                        // root->ac_root and root->ac_root->trans
                        // config and init filter filter_init, set all bits to 1:
                        // memset(m->B, ~0, sizeof(m->B));
                        // memset(m->end, ~0, sizeof(m->end));
            if(!root->ac_only) cli_bm_init // size = HASH(255, 255, 255) + 1;
                // allocate memory for root->bm_shift
                // root->bm_shift[i] = BM_MIN_LENGTH - BM_BLOCK_SIZE + 1;
        engine->root[1]->bm_offmode = 1; /* BM offset mode for PE files */
    target = (unsigned short) atoi(pt); // target is defined in each ndb record
    root = engine->root[target];
    cli_parse_add // add the pattern finally
```

add pattern: select algo – AC or BM

cli_parse_add

```
    if (hexsig[0] == '$') // case of ${min-max}MACROID$ for logic signatures
        // get min, max and MACROID
        sscanf(hexsig,"${%u-%u}%u$",&smin, &smax, &tid)    != 3)
        /* this is not a pattern that will be matched by AC itself, rather it is a
        * pattern checked by the lsig code */
        patt->ch_mindist[0] = smin;
        patt->ch_maxdist[0] = smax;
        patt->sigid = tid;
        patt->length = root->ac_mindepth;
        cli_ac_addpatt

    if((wild = strchr(hexsig, '{'))) // regular expression
        if(sscanf(wild, "%c%u%c", &l, &range, &r) == 3 && l == '{' && r == '}' &&
range > 0 && range < 128) // dealing case as “{a,b}”
          // change from "6f6f6f{4}6b6b6b" to "6f6f6f????????6b6b6b"
          hexcpy = cli_calloc(hexlen + 2 * range, sizeof(char));
          strncpy(hexcpy, hexsig, wild - hexsig);
          strcat(hexcpy, "??");
          wild = strchr(wild, '}')
          strcat(hexcpy, ++wild);
          //call again
          cli_parse_add(root, virname, hexcpy, rtype, type, offset, target, lsigid,
options);
        else // dealing case as “string{a,b}string{c,d}” - partial sigs
          root->ac_partsigs++;
          // find all the partial sigs
          for(i = 0; i < hexlen; i++)
             // each hex string besides “{}” or {*} will be split into two partial sigs
             if(hexsig[i] == '{' || hexsig[i] == '*')    parts++;
          // adding each sig into ac tire
          start = pt = hexcpy;
          for(i = 1; i <= parts; i++)
             for(j = 0; j < strlen(start); j++)
                 if(start[j] == '{') asterisk = 0; // has not asterisk
                 // dealing case as “string{a,b}string*string{c,d}” - partial sigs
                 if(start[j] == '*') asterisk = 1; // has asterisk
            ret = cli_ac_addsig(root, virname, start, root->ac_partsigs, parts, i, rtype,
type, mindist, maxdist, offset, lsigid, options)

    // each hex string besides “{}” or {*} will be split into two partial sigs
    if(strchr(hexsig, '*'))
        root->ac_partsigs++;
        for(i = 0; i < hexlen; i++)    if(hexsig[i] == '*')       parts++;
        for(i = 1; i <= parts; i++)
```

```
        pt = cli_strtok(hexsig, i - 1, "*")
        ret = cli_ac_addsig(root, virname, pt, root->ac_partsigs, parts, i, rtype,
type, 0, 0, offset, lsigid, options)

    if(root->ac_only || type || lsigid || strpbrk(hexsig, "?([") || (root->bm_offmode
&& (!strcmp(offset, "*") || strchr(offset, ','))) || strstr(offset, "VI") || strchr(offset,
'$')) // cases that also applies ac algo
    // ac_only
    // targeting specific file type instead of generic
    // PE's bm offset mode with offset defined in signature
    // have VI(version information) offset
    // enters here with '?'
        cli_ac_addsig

    if(the rest case) //numbers only
      cli_bm_addpatt
```

add signature(pre processing for regular expression) - AC

```
cli_ac_addsig
    new->ch[0] |= CLI_MATCH_IGNORE;
    new->ch[1] |= CLI_MATCH_IGNORE;
    // dealing case as "[]" – "HEXSIG[x-y]aa or aa[x-y]HEXSIG"
    if(strchr(hexsig, '[')) // with "[" – [] means a range, special case
      for(i = 0; i < 2; i++)
        pt = strchr(hex, '[')
        pt2 = strchr(pt, ']')
        sscanf(pt, "%u-%u", &n1, &n2) // AC_CH_MAXDIST=3
        if(strlen(hex) == 2)
          dec = cli_hex2ui(hex); // case "aa[x-y]HEXSIG"
          new->ch[i] = *dec;
          new->ch_mindist[i] = n1;
          new->ch_maxdist[i] = n2;
        if(strlen(pt2) == 2)
          dec = cli_hex2ui(pt2); // case "HEXSIG[x-y]aa"
          new->ch[i] = *dec;
          new->ch_mindist[i] = n1;
          new->ch_maxdist[i] = n2;
// special types
```

```
#define AC_SPECIAL_ALT_CHAR 1
#define AC_SPECIAL_ALT_STR  2
#define AC_SPECIAL_LINE_MARKER  3
#define AC_SPECIAL_BOUNDARY 4

#define AC_BOUNDARY_LEFT          1
#define AC_BOUNDARY_LEFT_NEGATIVE   2
#define AC_BOUNDARY_RIGHT         4
#define AC_BOUNDARY_RIGHT_NEGATIVE  8
#define AC_LINE_MARKER_LEFT      16
#define AC_LINE_MARKER_LEFT_NEGATIVE     32
#define AC_LINE_MARKER_RIGHT           64
#define AC_LINE_MARKER_RIGHT_NEGATIVE    128
```

```
    // dealing case as “()” – “(aa|bb|cc|..) or ! (aa|bb|cc|..) or (B) or (L)”
    if(strchr(hexsig, '(')) // with “(“ – () means or, special case
        start = pt = hexcpy;
        while((pt = strchr(start, '('))) // for each “()”
            /* struct cli_ac_special {
                unsigned char *str;
                struct cli_ac_special *next;
                uint16_t len, num;
                uint8_t type, negative;
            }; */
            newspecial = (struct cli_ac_special *) mpool_calloc(root->mempool, 1,
sizeof(struct cli_ac_special));
            if(pt >= hexcpy + 2) if(pt[-2] == '!') // case “! (aa|bb|cc|..)”
                newspecial->negative=1; // case “(aa|bb|cc|..)”
                                        // newspecial->negative = 0
            start = strchr(pt, ')')
            if(!strcmp(pt, "B")) // case “(B)”
                if(!*start)
                    new->boundary |= AC_BOUNDARY_RIGHT;
                    if(newspecial->negative)
                        new->boundary |= AC_BOUNDARY_RIGHT_NEGATIVE;
                if(pt - 1 == hexcpy)
                    new->boundary |= AC_BOUNDARY_LEFT;
                    if(newspecial->negative)
                        new->boundary |= AC_BOUNDARY_LEFT_NEGATIVE;
            if(!strcmp(pt, "L")) // case “(L)”
                if(!*start)
                    new->boundary |= AC_LINE_MARKER_RIGHT;
                    if(newspecial->negative)
                        new->boundary |= AC_LINE_MARKER_RIGHT_NEGATIVE;
                if(pt - 1 == hexcpy)
                    new->boundary |= AC_LINE_MARKER_LEFT;
                    if(newspecial->negative)
                        new->boundary |= AC_LINE_MARKER_LEFT_NEGATIVE;
```

```
        // create new special table with old one copied over
        new->special++;
        newtable = (struct cli_ac_special **) mpool_realloc(root->mempool,
new->special_table, new->special * sizeof(struct cli_ac_special *));
        newtable[new->special - 1] = newspecial;
        new->special_table = newtable;

        if(!strcmp(pt, "B"))    newspecial->type = AC_SPECIAL_BOUNDARY;
        if(!strcmp(pt, "L"))     newspecial->type = AC_SPECIAL_LINE_MARKER;
        else // case "(xx|yy|zz) or (a|b|c)"
            newspecial->num = 1;
            for(i = 0; i < strlen(pt); i++)
                if(pt[i] == '|') newspecial->num++;
            // case "(a|b|c)"
            if(3 * newspecial->num - 1 == (uint16_t) strlen(pt))
                newspecial->type = AC_SPECIAL_ALT_CHAR;
                newspecial->str = (unsigned char *) mpool_malloc(root->mempool,
newspecial->num);
            // case "(xx|yy|zz)
            else    newspecial->type = AC_SPECIAL_ALT_STR;

        for(i = 0; i < newspecial->num; i++)
            if(newspecial->num == 1) // case of only 1 "|"
                c = (char *) cli_mpool_hex2str(root->mempool, pt);
            else // case multiple "|"
                (h = cli_strtok(pt, i, "|")
                c = (char *) cli_mpool_hex2str(root->mempool, h);\
            // alternative chars stored in array and alternative strings stored in chain
            if(newspecial->type == AC_SPECIAL_ALT_CHAR)
                newspecial->str[i] = *c; // set the char
            else // string case
                if(i)
                    specialpt = newspecial;
                    // insert the string into chain of alterative
                    while(specialpt->next)
                        specialpt = specialpt->next;
                    specialpt->next = (struct cli_ac_special *)
mpool_calloc(root->mempool, 1, sizeof(struct cli_ac_special));
                    specialpt->next->str = (unsigned char *) c;
                else newspecial->str = (unsigned char *) c;
            // sort the char array
            if(newspecial->num>1 && newspecial->type == AC_SPECIAL_ALT_CHAR)
             cli_qsort(newspecial->str, newspecial->num, sizeof(unsigned char),
qcompare);
```

// dealing other case

new->pattern = cli_mpool_hex2ui(root->mempool, hex ? hex : hexsig);

// new->pattern is uint16_t

cli_mpool_hex2ui

cli_realhex2ui // in this function, each byte of the pattern would be extended to uint16_t(low byte for the pattern byte and high byte for the matching type corresponding to the regular expression type)

```
#define CLI_MATCH_WILDCARD  0xff00
#define CLI_MATCH_CHAR      0x0000
#define CLI_MATCH_IGNORE    0x0100
#define CLI_MATCH_SPECIAL   0x0200
#define CLI_MATCH_NIBBLE_HIGH   0x0300
#define CLI_MATCH_NIBBLE_LOW    0x0400
```

```
if(hex[i] == '?' && hex[i + 1] == '?')     val |= CLI_MATCH_IGNORE;
if(hex[i + 1] == '?')     val |= CLI_MATCH_NIBBLE_HIGH;
if(hex[i] == '?')     val |= CLI_MATCH_NIBBLE_LOW;
if(hex[i] == '(')     val |= CLI_MATCH_SPECIAL;
```

filter_add_acpatt //* prefiltering

// check if there's regex in first letters

if(new->pattern[i] & CLI_MATCH_WILDCARD)

cli_caloff //"test_ndb_regex:0:3,5:6f6f6f{4}6b6b6b"

```
if((pt = strchr(offcpy, ','))) offdata[2] = atoi(pt + 1); // which is 5
offdata[0] = CLI_OFF_ABSOLUTE;
*offset_min = offdata[1] = atoi(offcpy);    // which is 3
*offset_max = *offset_min + offdata[2]; // which is 8
```

cli_ac_addpatt

add pattern to AC tire

cli_ac_addpatt

uint16_t len = MIN(root->ac_maxdepth, pattern->length);

// root->ac_maxdepth is set via CLI_DEFAULT_AC_MAXDEPTH

for(i = 0; i < len; i++)

next = pt->trans[(unsigned char) (pattern->pattern[i] & 0xff)];

if(!next) // this tran does not yet exist

next = (struct cli_ac_node *) mpool_calloc(root->mempool, 1, sizeof(struct cli_ac_node)); // allocate

newtable = mpool_realloc(root->mempool, root->ac_nodetable, root->ac_nodes * sizeof(struct cli_ac_node *)); // allocate a new node table to copy over the old ones and store the new one, copy over is done automatically via mpool_realloc

```
        root->ac_nodetable = (struct cli_ac_node **) newtable;
        root->ac_nodetable[root->ac_nodes - 1] = next;
        // put into the tire-
        pt->trans[(unsigned char) (pattern->pattern[i] & 0xff)] = next;
      else
        pt = next // next char
    // create new pattern table and copy over
    newtable = mpool_realloc(root->mempool, root->ac_pattable, root->ac_patterns * sizeof(struct cli_ac_patt *));
    root->ac_pattable = (struct cli_ac_patt **) newtable;
    root->ac_pattable[root->ac_patterns - 1] = pattern;
    /*
    ac node would have a list of ac patterns that share the same prefix
    if there is pattern list, need to insert current one into it, sort according to the first 2 latters of the pattern
    also the ac tree only accept a max depth of 3
    */
    // pt is ac node and ph is ac pattern and now pt is pointing at leaf of this pattern in the ac tire
    ph = pt->list; // the list only exists when the last node in the ac tire is shared by other patterns
    ph_add_after = ph_prev = NULL;

    while(ph) // if leaf is shared by other patterns which is highly possible as only first 3 bytes of the signature is used to build the ac tire, then try to insert it to the shared pattern list, also of the pattern or subpattern are same, should also add into a structure called pattern->next_same
    // compare partno???

    if(!ph_add_after && ph->partno <= pattern->partno && (!ph->next || ph->next->partno > pattern->partno))
        ph_add_after = ph;
    // same pattern length, same prefix length and same first two letters
    // ending in same leaf, need to further confirm if the two pattern are same or similar

    if((ph->length == pattern->length) && (ph->prefix_length == pattern->prefix_length) && (ph->ch[0] == pattern->ch[0]) && (ph->ch[1] == pattern->ch[1]))
        // if the characters part of the two pattern are exact the same, compare other info in the signature

        if(!memcmp(ph->pattern, pattern->pattern, ph->length * sizeof(uint16_t))
    && !memcmp(ph->prefix, pattern->prefix, ph->prefix_length * sizeof(uint16_t)))
```

```
            // if no other regex special case, the two sig are exact match
            if(!ph->special && !pattern->special) match = 1
            if(ph->special == pattern->special)
                //compare the special info
                a1 = ph->special_table[i];
                a2 = pattern->special_table[i];
            else match = 0;
            if(match) // sig info is the same
                // insert into next_same(same signature list) and sorting according to partno
                if(pattern->partno < ph->partno)
                    pattern->next_same = ph; // insert into same pattern list
                    if(ph_prev) ph_prev->next = ph->next; // remove ph from the leaf node's pattern list since it is added into same pattern list of current pattern
                    else pt->list = ph->next; // removing from current pattern's list
                else
                     while(ph->next_same && ph->next_same->partno < pattern->partno)
                        ph = ph->next_same;
                    pattern->next_same = ph->next_same;
                    ph->next_same = pattern;

        else
            // try next pattern in the list
            ph_prev = ph;
            ph = ph->next;

    if(ph_add_after) // insert
        pattern->next = ph_add_after->next;
        ph_add_after->next = pattern;
    else // append in head
        pattern->next = pt->list;
        pt->list = pattern;
```

compile the tire to build the data structure for ac scan(build goto/fail/jump table)

```
cl_engine_compile
  cli_loadftm // load supported file format
  cli_ac_buildtrie
   ac_maketrans // compile the ac tire to build goto/fail/jump table
```

ac_maketrans

```
/*
three tables are needed: goto/fail/jump
1    goto table is automatically built via trans[] table
2    the size of each trans table is 256 - the size of ASCII table
3    fail and jump table are built in this function
*/

// bellow calculate the fail table
// enqueue the child nodes of ac_root
for(i = 0; i < 256; i++)
        node = ac_root->trans[i];
        // init any none existing root's tran as ac_root
        if(!node) ac_root->trans[i] = ac_root;
        else
                // init the fail node as ac_root
                node->fail = ac_root
                // enqueue a tran that exists
                ret = bfs_enqueue(&bfs, &bfs_last, node)

// deal with each node in the same level
while((node = bfs_dequeue(&bfs, &bfs_last)))
        // deal with leaf node
        /* if is leaf node, will have no trans table and the way calculating fail node would be a little bit different, need to find a fail node in the fail node chain that is not leaf node */
        if(IS_LEAF(node))
                while(IS_LEAF(failtarget)) failtarget = failtarget->fail;
                node->fail = failtarget;
        // deal with middle level node
        for(i = 0; i < 256; i++)
                child = node->trans[i];
                if(child)
                        fail = node->fail;
                        // leaf or no such tran in fail node, move forward along the node chain
                        while(IS_LEAF(fail) || !fail->trans[i])      fail = fail->fail;
                        child->fail = fail->trans[i];
                        ret = bfs_enqueue(&bfs, &bfs_last, child)

// bellow calculate the jump table
for(i = 0; i < 256; i++)
        node = ac_root->trans[i];
        // enqueue the existing tran
```

```
    if(node != ac_root)     (ret = bfs_enqueue(&bfs, &bfs_last, node)

while((node = bfs_dequeue(&bfs, &bfs_last)))
    // jump table is not needed for leaf node
    if(IS_LEAF(node)) continue
    for(i = 0; i < 256; i++)
        child = node->trans[i];
        // if node has no such tran or is leaf and has no list and no tran
        // this is an useless node and jump to fail node
        if (!child || (!IS_FINAL(child) && IS_LEAF(child)))
            // mode forward along the fail table chain
            while(IS_LEAF(failtarget) || !failtarget->trans[i])
                failtarget = failtarget->fail;
            failtarget = failtarget->trans[i];
            node->trans[i] = failtarget; // jump to fail node
        // node is leaf and final(output) node, there is a match
        if (IS_FINAL(child) && IS_LEAF(child))
            origlist = list = child->list;
            if (list)
                while (list->next) list = list->next;
                // chain up with fail node's list – means:
                // 1. One match is done
                // 2. Match next signature with prefix as current signature
                list->next = child->fail->list;
            else
                child->list = child->fail->list;
            // 2. Match next signature with prefix as current signature
            child->trans = child->fail->trans;
        else
            bfs_enqueue(&bfs, &bfs_last, child)
```

Scan

scan logic design

there are 4 scan methods

1. BM
2. AC
3. Hash
4. Bytecode

There are 2 entry points to begin a scan: cli_map_scandesc and cli_magic_scandesc
cli_map_scandesc will scan a file that is mapped to virtual memory already, this method is not yet used except in unit test case.
cli_magic_scandesc however is used for now as the primary entry of a scan and actually in a later stage, the file to be scanned will be mapped to memory also.

Before the actual scan, the type of the file is assumed as CL_TYPE_ANY, and the actual type of the incoming file would be decided with cli_filetype2 at magic_scandesc

After the filetype is decided, specific scan function dedicated to the file will be called directly. However, for ASCII file, - CL_TYPE_TEXT_ASCII, the scan will only be called with certain config. So for ascii file, cli_scanraw will be called to make the scan.

In raw scan, ASCII type will be assumed as CL_TYPE_ANY again and calling cli_fmap_scandesc to do further scan.

In cli_fmap_scandesc, according to **ftonly**(if configured as scan specific file type only) and **ftype**(the type of the file which will further decide the root to load) to decide the db to load and scan algo to use in match_run:

- Generic db or type specific db
- BM(normal signature mode or offset mode, currently off mode is only enabled for PE type) or AC or Hash scan
- Hash scan will be performed if BM and AC scan return clean
- If hash scan is clean also, then logic code scan/bytecode scan will be performed via calling cli_lsig_eval and further cli_magic_scandesc_type(mormal BM/AC scan), matchicon or cli_bytecode_runlsig(bytecode scan)
- Bytecode scan will be run finally via cli_bytecode_run
- Bytecode scan can also be triggered via cli_pdf and cli_scanpe
- The bytecode scan will be finally done at cli_vm_execute

In matcher_run, a prefiltering(filter_search_ext) is called to reduce the length of actual scan if possible. After that, BM scan firstly and AC scan later is performed to match against the virus db loaded

The ac scan

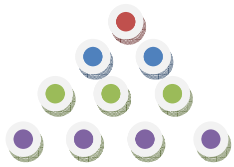
cli_ac_scanbuff

// if loading part sigs or logic sigs or relative offset sigs, we need mdata to exist
// and the mdata has format of cli_ac_data

```
struct cli_ac_data {
    int32_t ***offmatrix;
    uint32_t partsigs, lsigs, reloffsigs;
    uint32_t **lsigcnt;
    uint32_t **lsigsuboff_last, **lsigsuboff_first;
    uint32_t *offset;
    uint32_t macro_lastmatch[32];
    /** Hashset for versioninfo matching */
    const struct cli_hashset *vinfo;
    uint32_t min_partno;
};
```

```
if(!mdata && (root->ac_partsigs || root->ac_lsigs || root->ac_reloff_num))
// return ERROR

current = root->ac_root
// looping over the buffer of a file content
for(i = 0; i < length; i++)
    // the follow the tran
    current = current->trans[buffer[i]];
    // UNLIKELY - return 0 if true(if condition(IS_FINAL(current)) is 0)
    // return 1 if false
    if(UNLIKELY(IS_FINAL(current))) //return 1(IS_FINAL(current) is true) means it is a final(have list) node
      /* comments for the list:
         As the ac tire only have 4 levels with root taken into account
```



```
        So if first 2 characters of the signature are same, these sigs would be ending
        in the same leaf node linked via list
      */
      patt = current->list;
      // loop over all patterns in the list
      while(patt)
        // for sig with part sigs, if current sig's part sig count is less than required minimum for this type of file, jump forward via fail table
        patt = faillist; continue;
        bp = i + 1 - patt->depth; //"STARTooo" i=7, depth=3 CHR
        // if sig is not for specific file types or special sig types(e.g.: macro or logic sig or pe files
        if(patt->offdata[0] != CLI_OFF_VERSION && patt->offdata[0] != CLI_OFF_MACRO && !patt->next_same && (patt->offset_min != CLI_OFF_ANY) && (!patt->sigid || patt->partno == 1))
          if(patt->offset_min == CLI_OFF_NONE)
            patt = patt->next; continue; // try next pattern in pattern list
          realoff = offset + bp - patt->prefix_length; // realoff=5
```

```
// yes for this case
if(patt->offdata[0] == CLI_OFF_ABSOLUTE)
   // out of range, no for this case
   if(patt->offset_max < realoff || patt->offset_min > realoff)
      patt = patt->next; continue;// try next pattern in pattern list
else
  // max=8 and min=3, no for this case
  if(mdata->offset[patt->offset_min] == CLI_OFF_NONE || mdata->offset[patt->offset_max] < realoff || mdata->offset[patt->offset_min] > realoff)
      patt = patt->next; continue;// try next pattern in pattern list

pt = patt; // the pattern
// ac_findmatch – match all the special cases for regular expression
if(ac_findmatch(buffer, bp, offset + bp - patt->prefix_length, length, patt, &matchend))
// if there's a match, loop over the next_same list
   while(pt)
      // break if sig part count is big than needed one
      if(pt->partno > mdata->min_partno) break;
      /* AC_SCAN_FT – scan file type
         AC_SCAN_VIR –scan virus
      */
      if((pt->type && !(mode & AC_SCAN_FT)) || (!pt->type && !(mode & AC_SCAN_VIR)))
         pt = pt->next_same; continue; // try next pattern in next_same list
       realoff = offset + bp - pt->prefix_length;

       if(pt->offdata[0] == CLI_OFF_VERSION) // no for this case
       if(pt->offdata[0] == CLI_OFF_MACRO) // no for this case
       // yes for this case
       if(pt->offset_min != CLI_OFF_ANY && (!pt->sigid || pt->partno == 1))
          if(pt->offset_min == CLI_OFF_NONE) // no for this case
             pt = pt->next_same;continue;//try next pattern in next_same list
          if(pt->offdata[0] == CLI_OFF_ABSOLUTE) // yes for this case
             // no for this case
             if(pt->offset_max < realoff || pt->offset_min > realoff)
                //try next pattern in next_same list
                pt = pt->next_same;continue;
          else
             if(mdata->offset[pt->offset_min] == CLI_OFF_NONE || mdata->offset[pt->offset_max] < realoff || mdata->offset[pt->offset_min] > realoff)
                //try next pattern in next_same list
                pt = pt->next_same;continue;
```

```
 /* it's a partial signature, no for this case */
if(pt->sigid)
   // TBD TBD TBD

 /* old type signature, yes for this case */
else
```