Fuzzing Malware for Fun & Profit. Applying Coverage-Guided Fuzzing to Find Bugs in Modern Malware

Maksim Shudrak

DEF CON 26

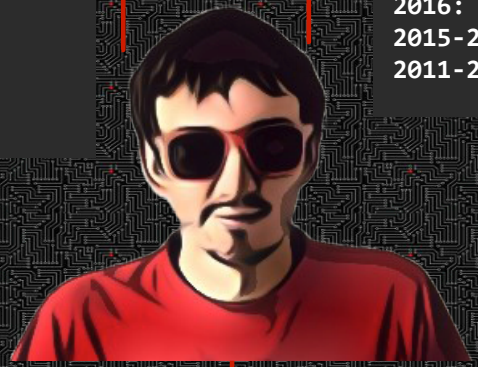
About Me

Interests

Vulnerabilities Hunting
Fuzzing
Reverse-engineering
Malware Analysis
Dynamic Binary Instrumentation

BIO

2018 – present: Senior Offensive Security Researcher
2016: Defended PhD (Vulns Hunting) in Tomsk, Russia
2015-2017: Researcher, IBM Research, Haifa, Israel
2011-2015: Security Researcher, PhD student



Projects

Drltrace – transparent API-calls tracing for malware analysis
https://github.com/mxmssh/drltrace
WinHeap Explorer – PoC for heap-based bugs detection in x86 code
https://github.com/WinHeapExplorer/WinHeap-Explorer
IDAMetrics – IDA plugin for machine code complexity assessment
https://github.com/mxmssh/IDAmetrics



Introduction & Motivation



Why coverage-guided fuzzing ?



Fuzzer overview & architecture



Fuzzer usage & demo



Case Studies. Mirai + vulnerability demo



Case Studies. TinyNuke, KINS, Dexter



Discussion, Future Work & Conclusion

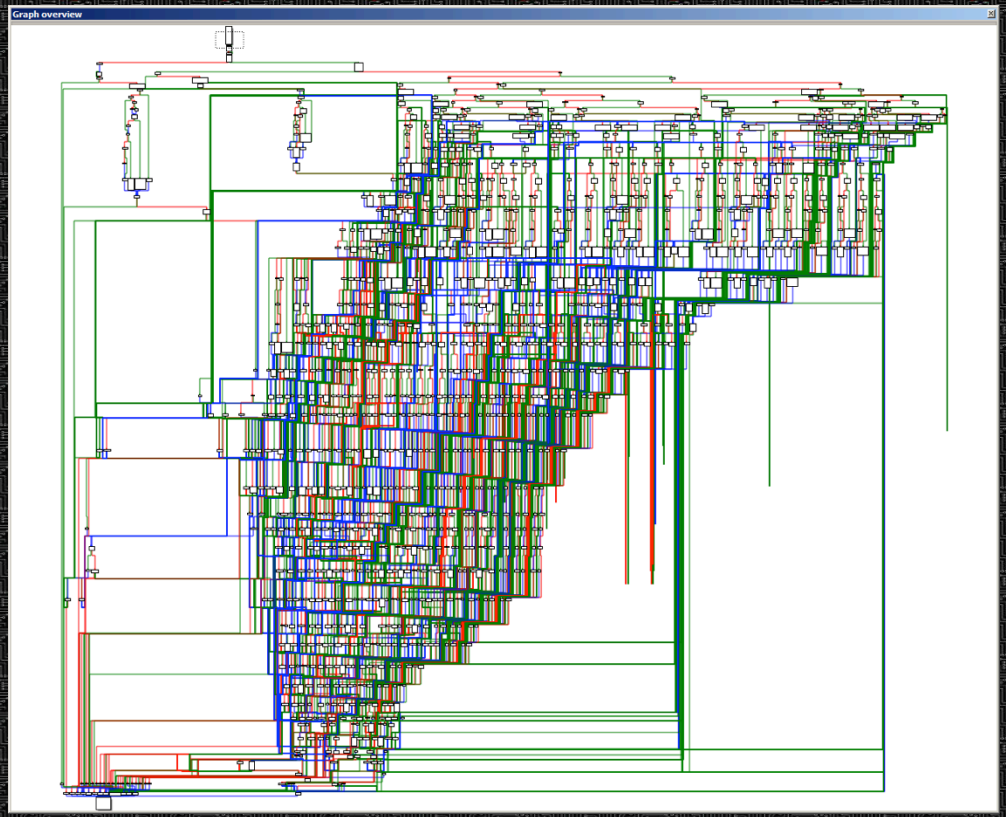
Motivation . Complex Parsers

```
__int32 __cdecl Nspr4Hook::hookerPrWrite(void *fd, const void *buf, __int32 amount)
{
#if defined WDEBUG1
  WDEBUG1(WDDT_INFO, "Called, amount=%i.", amount);
#endif

  if(Core::isActive() && buf != NULL && amount > 0)
  {
    /*
      Я просто [redacted] писать этот алгоритм. - ☺
    */
    CWA(kernel32, EnterCriticalSection)(&connectionsCs);
    DWORD connectionIndex = connectionFind((PRFILEDESC *)fd);
    if(connectionIndex != (DWORD)-1)
    {
      NSPR4CONNECTION *nc = &connections[connectionIndex];
#     if defined WDEBUG1
      WDEBUG1(WDDT_INFO, "Connection 0x%p founded in table.", fd);
#     endif
```

Motivation . Complex Parsers

```
__int32 __cdecl Nspr4Hook::hookerPrWrite(void *fd, const void *buf, __int32 amount)
{
#if defined WDEBUG1
  WDEBUG1(WDDT_INFO, "Called, amount=%i.", amount);
#endif

  if(Core::isActive() && buf != NULL && amount > 0)
  {
    /*
      I am so #@$%^* tired of writing this algorithm.
    */
    CWA(kernel32, EnterCriticalSection)(&connectionsCs);
    DWORD connectionIndex = connectionFind((PRFILEDESC *)fd);
    if(connectionIndex != (DWORD)-1)
    {
      NSPR4CONNECTION *nc = &connections[connectionIndex];
#     if defined WDEBUG1
      WDEBUG1(WDDT_INFO, "Connection 0x%p founded in table.", fd);
#     endif
```

Motivation . Complex Parsers



Motivation. Low Code Quality



MalwareTech @MalwareTechBlog · Jul 7

I finally got the malware sample I was analyzing to give me what I wanted then it immediately crashes because the code was badly written. 😭

4 2 70

Motivation. It is Fun!



Related Works

- DEF CON 25 Offensive Malware Analysis: Dissecting OSX/FruitFly via a Custom C&C Server by Patrick Wardle
- DEF CON 25 Digital Vengeance: Exploiting the Most Notorious C&C Toolkits by Professor Plum
- Targeted attacks: From being a victim to counter attacking by Andrzej Dereszowski (SIGNAL 11)
- Malware fuzzing:
  - Rasthofer, S., Arzt, S., Triller, S. and Pradel, M., 2017, May. Making malory behave maliciously: Targeted fuzzing of android execution environments. In Software Engineering (ICSE), 2017 IEEE/ACM 39th International Conference on (pp. 300-311). IEEE.
  - F. Peng, Z. Deng, X. Zhang, D. Xu, Z. Lin, and Z. Su. X-force: Force executing binary programs for security applications. In Proceedings of the 2014 USENIX Security Symposium, San Diego, CA (August 2014), 2014

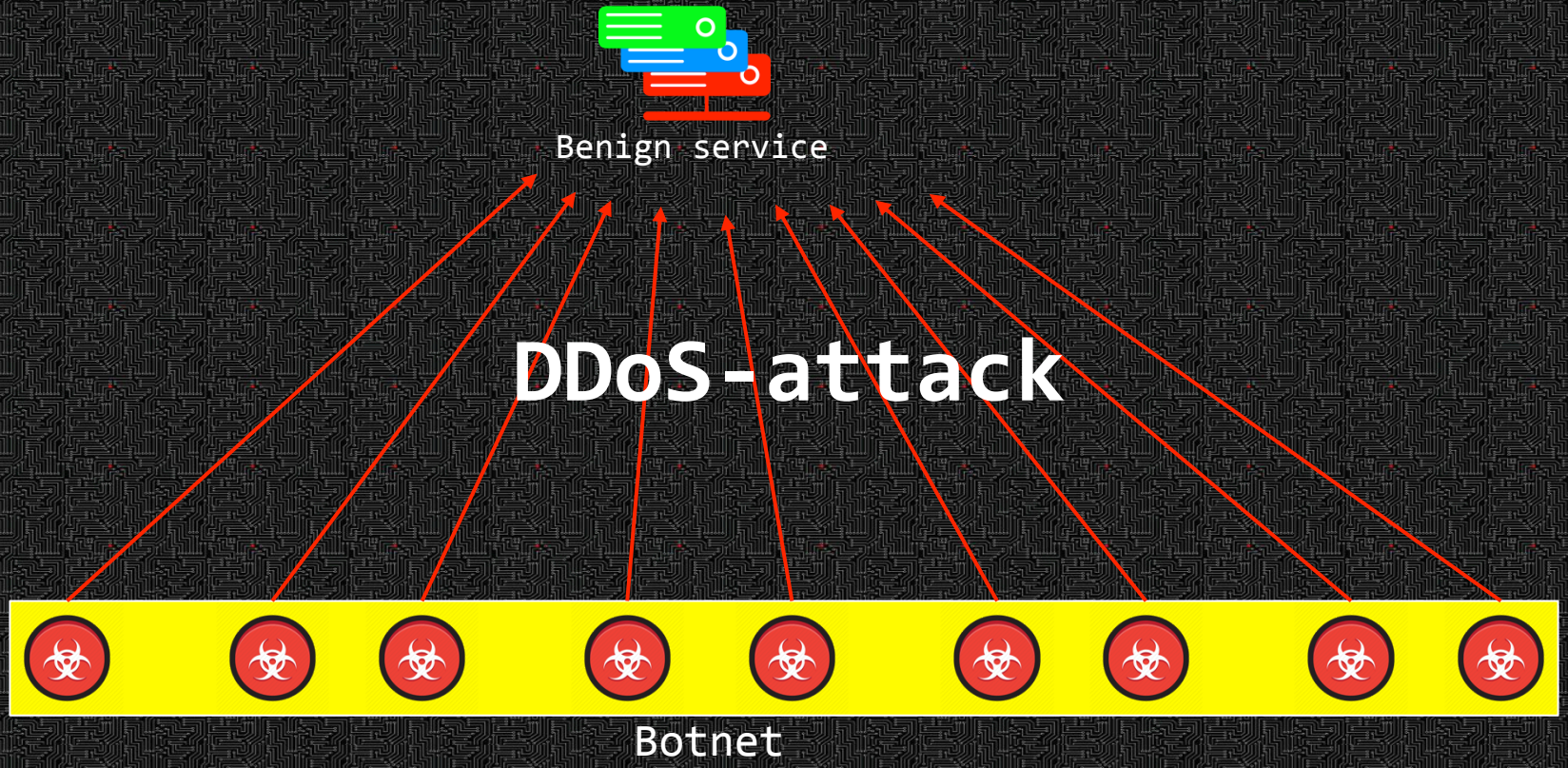
Legal Issues

- Hacking-back is mostly illegal
  - Attack attribution is very hard and might lead to wrong conclusions
  - Hard to identify scopes of attack
  - Check out last year DEF CON Professor Plum's presentation for more details:
    - https://www.youtube.com/watch?v=fPhkmAdWH-I
- BUT no one can prohibit us to search for bugs in malware

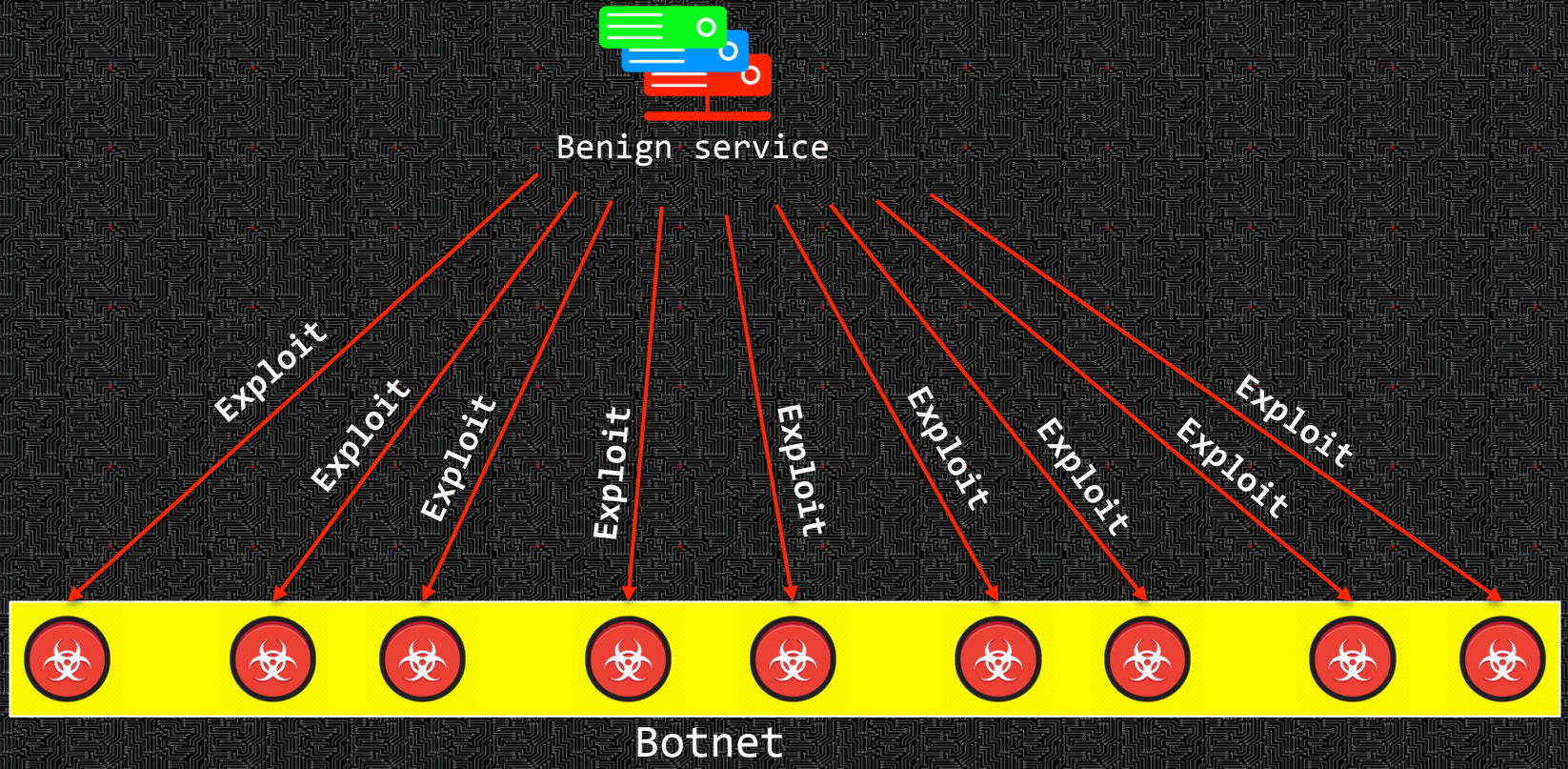
Possible Benefits. Local Deny of Service (agent)



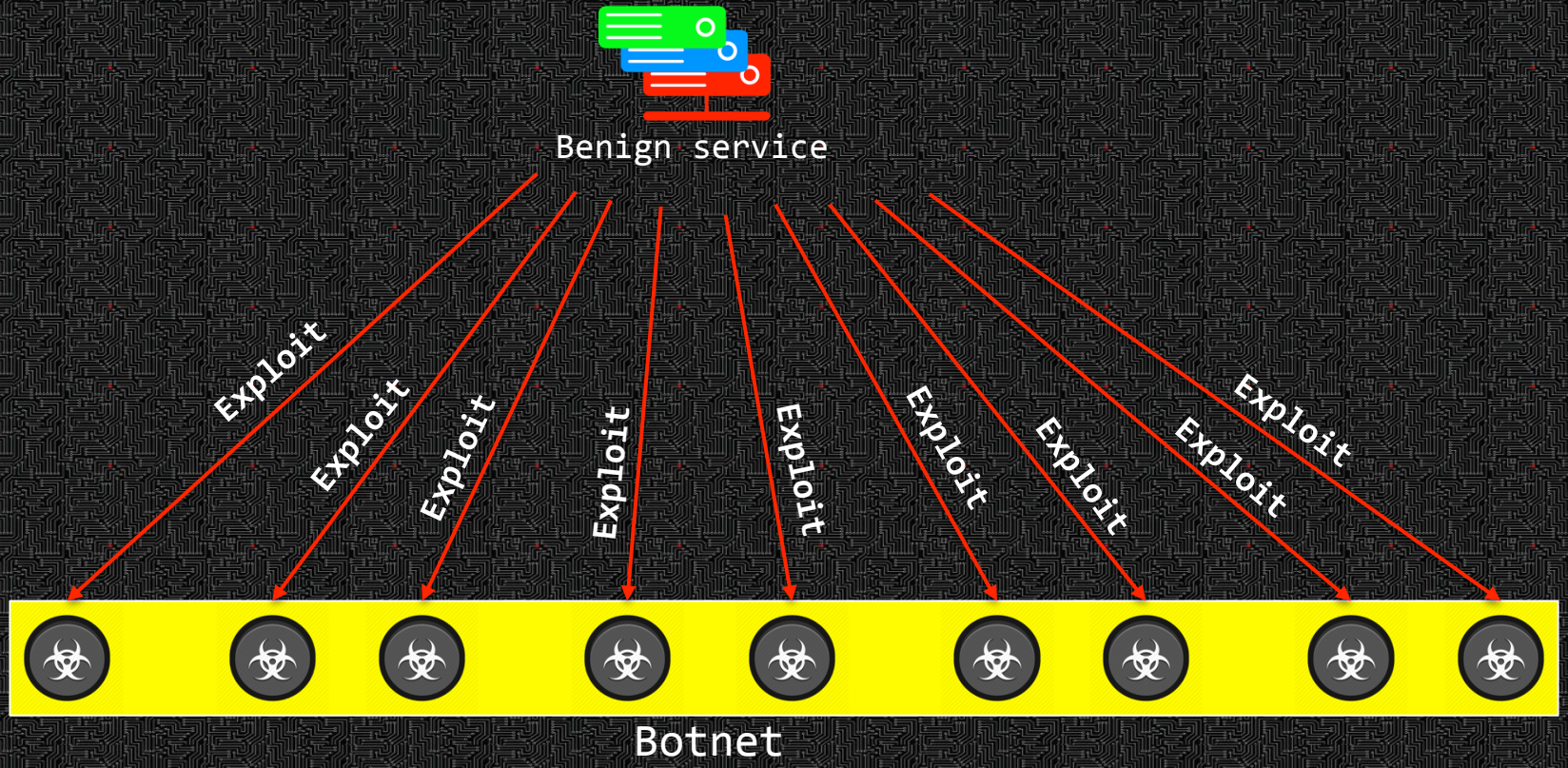
Possible Benefits. Remote Deny of Service (agent)



Possible Benefits. Remote Deny of Service (agent)



Possible Benefits. Remote Deny of Service (agent)



Possible Benefits. Remote Code Execution (agent)

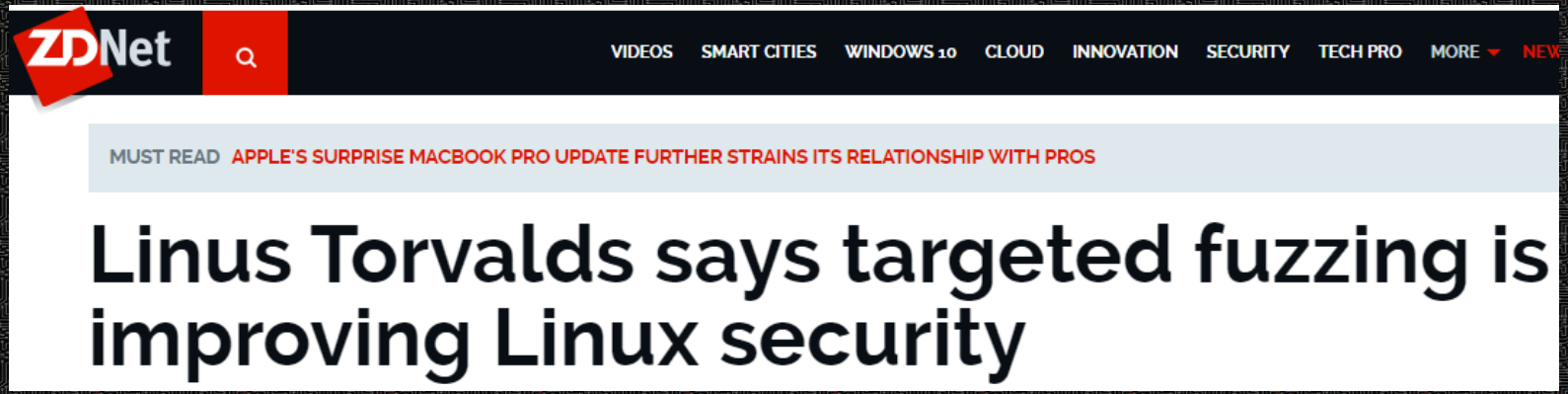
1. Take control over botnet or shutdown botnet
2. Track down botnet owners
3. ?????
4. PROFIT

Possible Benefits. Remote Code Execution in C&C



Fuzzing

- Nowadays, fuzzing is a state-of-the-art approach to find bugs in modern applications
- Fuzzing is a part of SDLC
- Fuzzing is very important for applications & OS security

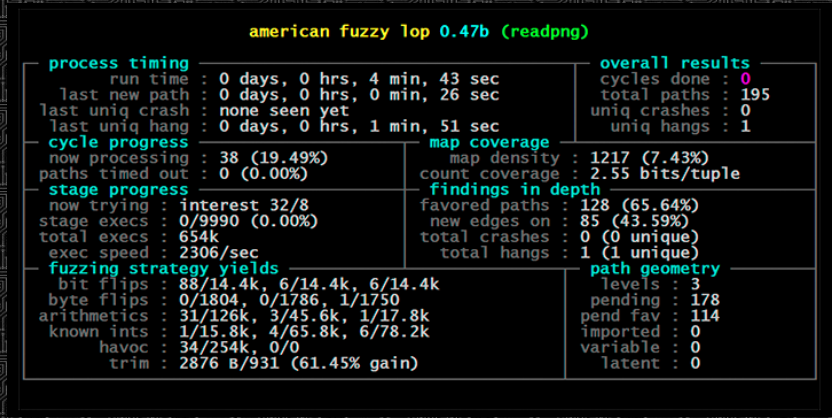


Fuzzing


afl-fuzz -i in -o out target @@
overall results
cycles done : 0
total paths : 146
uniq crashes : 0
uniq hangs : 0
3 hours later
overall results
cycles done : 0
total paths : 146
uniq crashes : 1
uniq hangs : 0

What is Coverage-Guided Fuzzing ?

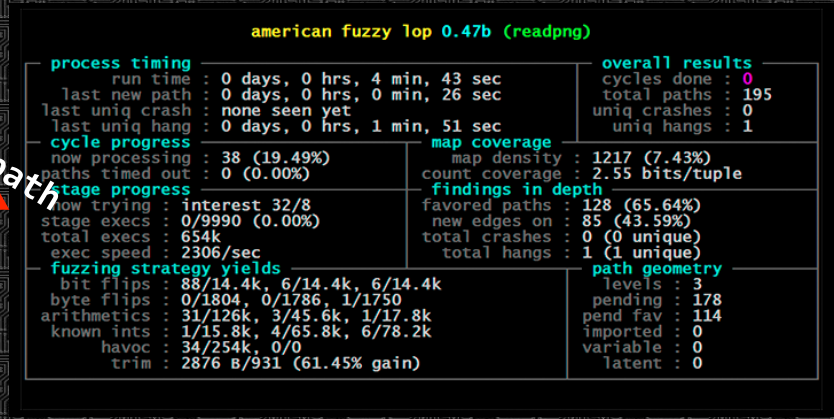
```
AiJsonError ParseValue(AiJson *json, char **str, AiJsonValue *value)
{
    AiJsonError err;
    switch(**str)
    {
        case CHAR_STR_OPEN_CLOSE:
        {
            char *data;
            value->type = AI_JSON_STRING;
            err = ParseString(json, str, &data);
            if(err != AI_JSON_E_OK)
                return err;
            value->data.string = data;
            break;
        }
        case CHAR_OBJECT_OPEN:
        {
            value->type = AI_JSON_OBJECT;
            value->data.object = JsonListCreate(json);
            if(!value->data.object)
                return AI_JSON_E_ALLOC;
            err = ParseObject(json, str, value->data.array);
            if(err != AI_JSON_E_OK)
                return err;
            break;
        }
        case CHAR_ARRAY_OPEN:
        {
            value->type = AI_JSON_ARRAY;
            value->data.array = JsonListCreate(json);
            if(!value->data.array)
                return AI_JSON_E_ALLOC;
            err = ParseArray(json, str, value->data.array);
            if(err != AI_JSON_E_OK)
                return err;
            break;
```



What is Coverage-Guided Fuzzing ?

```
AiJsonError ParseValue(AiJson *json, char **str, AiJsonValue *value)
{
    AiJsonError err;
    switch(**str)
    {
        case CHAR_STR_OPEN_CLOSE:
        {
            char *data;
            value->type = AI_JSON_STRING;
            err = ParseString(json, str, &data);
            if(err != AI_JSON_E_OK)
                return err;
            value->data.string = data;
            break;
        }
        case CHAR_OBJECT_OPEN:
        {
            value->type = AI_JSON_OBJECT;
            value->data.object = JsonListCreate(json);
            if(!value->data.object)
                return AI_JSON_E_ALLOC;
            err = ParseObject(json, str, value->data.array);
            if(err != AI_JSON_E_OK)
                return err;
            break;
        }
        case CHAR_ARRAY_OPEN:
        {
            value->type = AI_JSON_ARRAY;
            value->data.array = JsonListCreate(json);
            if(!value->data.array)
                return AI_JSON_E_ALLOC;
            err = ParseArray(json, str, value->data.array);
            if(err != AI_JSON_E_OK)
                return err;
            break;
```

Record new path



What is Coverage-Guided Fuzzing ?

```
AiJsonError ParseValue(AiJson *json, char **str, AiJsonValue *value)
{
    AiJsonError err;
    switch(**str)
    {
        case CHAR_STR_OPEN_CLOSE:
        {
            char *data;
            value->type = AI_JSON_STRING;
            err = ParseString(json, str, &data);
            if(err != AI_JSON_E_OK)
                return err;
            value->data.string = data;
            break;
        }
        case CHAR_OBJECT_OPEN:
        {
            value->type = AI_JSON_OBJECT;
            value->data.object = JsonListCreate(json);
            if(!value->data.object)
                return AI_JSON_E_ALLOC;
            err = ParseObject(json, str, value->data.array);
            if(err != AI_JSON_E_OK)
                return err;
            break;
        }
        case CHAR_ARRAY_OPEN:
        {
            value->type = AI_JSON_ARRAY;
            value->data.array = JsonListCreate(json);
            if(!value->data.array)
                return AI_JSON_E_ALLOC;
            err = ParseArray(json, str, value->data.array);
            if(err != AI_JSON_E_OK)
                return err;
            break;
```

Record new path

```
american fuzzy lop 0.47b (readpng)

process timing                                  overall results
        run time : 0 days, 0 hrs, 4 min, 43 sec     cycles done : 0
   last new path : 0 days, 0 hrs, 0 min, 26 sec     total paths : 195
last uniq crash : none seen yet                    uniq crashes : 0
last uniq hang : 0 days, 0 hrs, 1 min, 51 sec       uniq hangs : 1
cycle progress                                  map coverage
  now processing : 38 (19.49%)                    map density : 1217 (7.43%)
 paths timed out : 0 (0.00%)                   count coverage : 2.55 bits/tuple
stage progress                                  findings in depth
  now trying : interest 32/8                    favored paths : 128 (65.64%)
 stage execs : 0/9990 (0.00%)                    new edges on : 85 (43.59%)
 total execs : 654k                             total crashes : 0 (0 unique)
  exec speed : 2306/sec                          total hangs : 1 (1 unique)
fuzzing strategy yields                         path geometry
   bit flips : 88/14.4k, 6/14.4k, 6/14.4k           levels : 3
  byte flips : 0/1804, 0/1786, 1/1750             pending : 178
 arithmetics : 31/126k, 3/45.6k, 1/17.8k         pend fav : 114
  known ints : 1/15.8k, 4/65.8k, 6/78.2k          imported : 0
       havoc : 34/254k, 0/0                       variable : 0
        trim : 2876 B/931 (61.45% gain)             latent : 0
```

What is Coverage-Guided Fuzzing ?

```
AiJsonError ParseValue(AiJson *json, char **str, AiJsonValue *value)
{
    AiJsonError err;
    switch(**str)
    {
        case CHAR_STR_OPEN_CLOSE:
        {
            char *data;
            value->type = AI_JSON_STRING;
            err = ParseString(json, str, &data);
            if(err != AI_JSON_E_OK)
                return err;
            value->data.string = data;
            break;
        }
        case CHAR_OBJECT_OPEN:
        {
            value->type = AI_JSON_OBJECT;
            value->data.object = JsonListCreate(json);
            if(!value->data.object)
                return AI_JSON_E_ALLOC;
            err = ParseObject(json, str, value->data.array);
            if(err != AI_JSON_E_OK)
                return err;
            break;
        }
        case CHAR_ARRAY_OPEN:
        {
            value->type = AI_JSON_ARRAY;
            value->data.array = JsonListCreate(json);
            if(!value->data.array)
                return AI_JSON_E_ALLOC;
            err = ParseArray(json, str, value->data.array);
            if(err != AI_JSON_E_OK)
                return err;
            break;
```

Record new path

```
american fuzzy lop 0.47b (readpng)

process timing                                  overall results
        run time : 0 days, 0 hrs, 4 min, 43 sec     cycles done : 0
   last new path : 0 days, 0 hrs, 0 min, 26 sec     total paths : 195
last uniq crash : none seen yet                    uniq crashes : 0
last uniq hang : 0 days, 0 hrs, 1 min, 51 sec       uniq hangs : 1
cycle progress                                  map coverage
  now processing : 38 (19.49%)                    map density : 1217 (7.43%)
 paths timed out : 0 (0.00%)                   count coverage : 2.55 bits/tuple
stage progress                                  findings in depth
  now trying : interest 32/8                    favored paths : 128 (65.64%)
 stage execs : 0/9990 (0.00%)                    new edges on : 85 (43.59%)
 total execs : 654k                             total crashes : 0 (0 unique)
  exec speed : 2306/sec                          total hangs : 1 (1 unique)
fuzzing strategy yields                         path geometry
   bit flips : 88/14.4k, 6/14.4k, 6/14.4k          levels : 3
  byte flips : 0/1804, 0/1786, 1/1750            pending : 178
 arithmetics : 31/126k, 3/45.6k, 1/17.8k        pend fav : 114
  known ints : 1/15.8k, 4/65.8k, 6/78.2k        imported : 0
       havoc : 34/254k, 0/0                     variable : 0
        trim : 2876 B/931 (61.45% gain)           latent : 0
```

Why Coverage-Guided Fuzzing ?

~minutes for AFL and thousand years for dump fuzzer

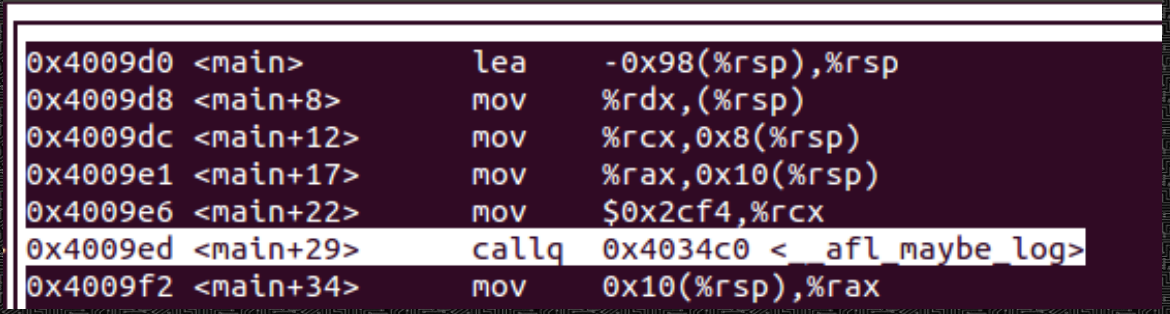
```
18      if (userBuffer[0] == 'P'){
19          if (userBuffer[1] == 'w'){
20              if (userBuffer[2] == 'n'){
21                  if (userBuffer[3] == 'T'){
22                      if (userBuffer[4] == 'o'){
23                          if (userBuffer[5] == 'w'){
24                              if (userBuffer[6] == 'n'){
25                              /* hell yeah */
26                              ((VOID(*)())0x0)();
27                              }
28                          }
29                      }
30                  }
31              }
32          }
33      }
```

State-of-the-art Coverage-Guided Fuzzers

- AFL
  - http://lcamtuf.coredump.cx/afl/
- Libfuzzer
  - https://llvm.org/docs/LibFuzzer.html
- AFL's forks
  - kAFL – AFL for kernel-level fuzzing
  - WinAFL – AFL fork for Windows binaries fuzzing
  - and many others: https://github.com/mirrorer/afl/blob/master/docs/sister_projects.txt

AFL Source Code Instrumentation Approach

- Custom gcc (afl-gcc) compiler is used to inject instrumentation routines for each basic block
- Main routine after instrumentation looks like this:



Challenge I. Source Code

No Source Code



```
Size = sizeof(UserAgent);
_memset(UserAgent,0x00,Size);
ObtainUserAgentString(0,UserAgent,&Size);
if(UserAgent[0]==0x00) { lstrcpy(UserAgent,"Mozilla/4.0(compatible; MSIE 7.0b; Windows

while((hOpen = InternetOpen(UserAgent,INTERNET_OPEN_TYPE_PRECONFIG,NULL,NULL,0)) == NU

x = 0;
ValidIndex = FALSE;
AlreadyConnected = FALSE;
PresistInfo = FALSE;
while(1) { //Start enumerating URLs till you find working one

if(Urls[x]==0x00) {
        x = 0;
        Sleep(ConnectInterval);
}
```

Challenge II. Obfuscation



Challenge III. Encryption

- Most C&C channels are encrypted
- We need to encrypt our test case the same way as malware to be able to find bugs
- By default, AFL doesn’t support encryption, checksums and crypto signatures generation
  - There is a post processor library to deal with that

WinAFL

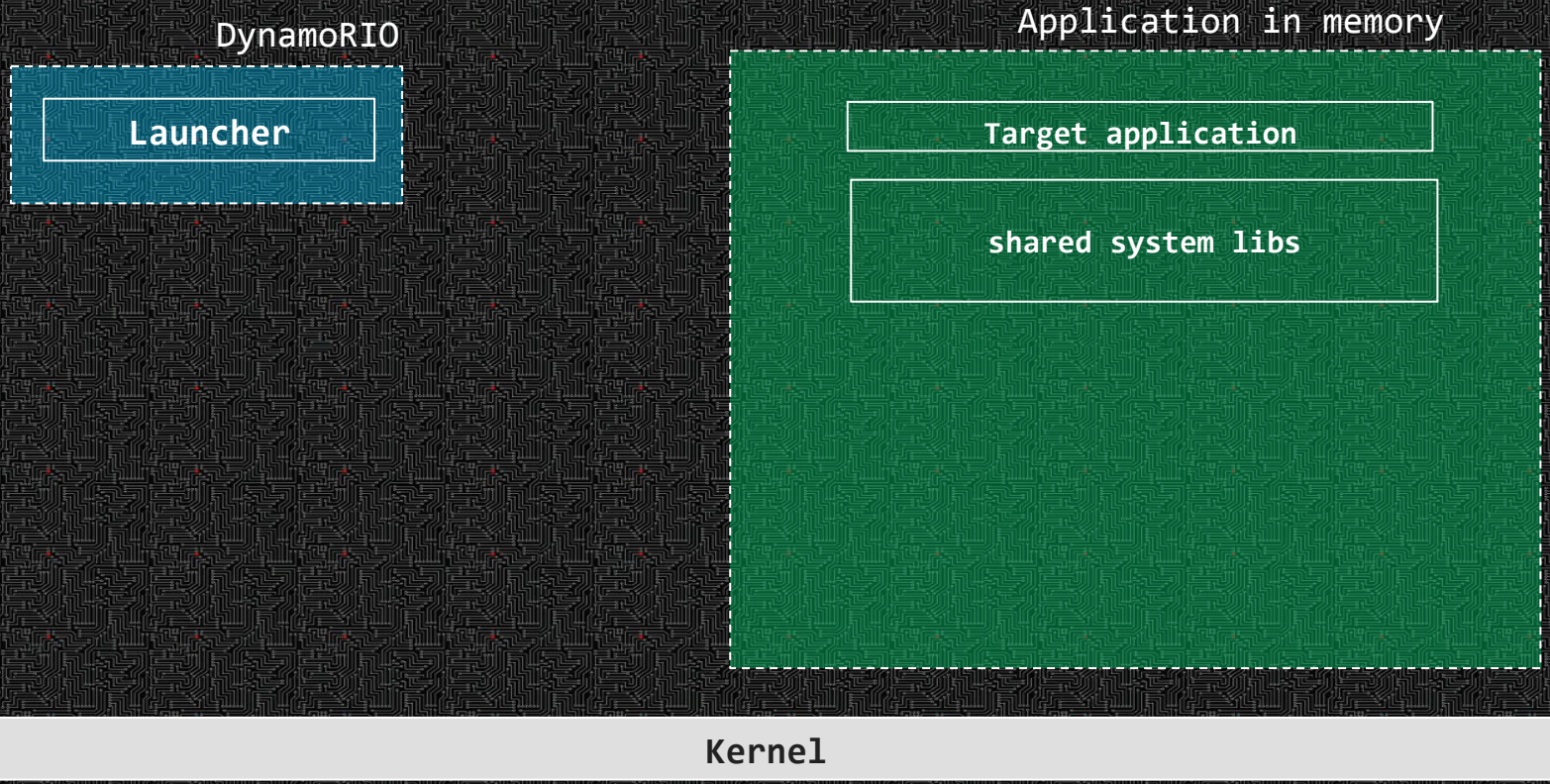
- WinAFL is a port of AFL for Windows. Rely on DynamoRIO dynamic binary instrumentation framework.
  - No need for source code access
  - Open-source
  - Fast-enough to use for coverage-guided fuzzing

    https://github.com/ivanfratric/winafl

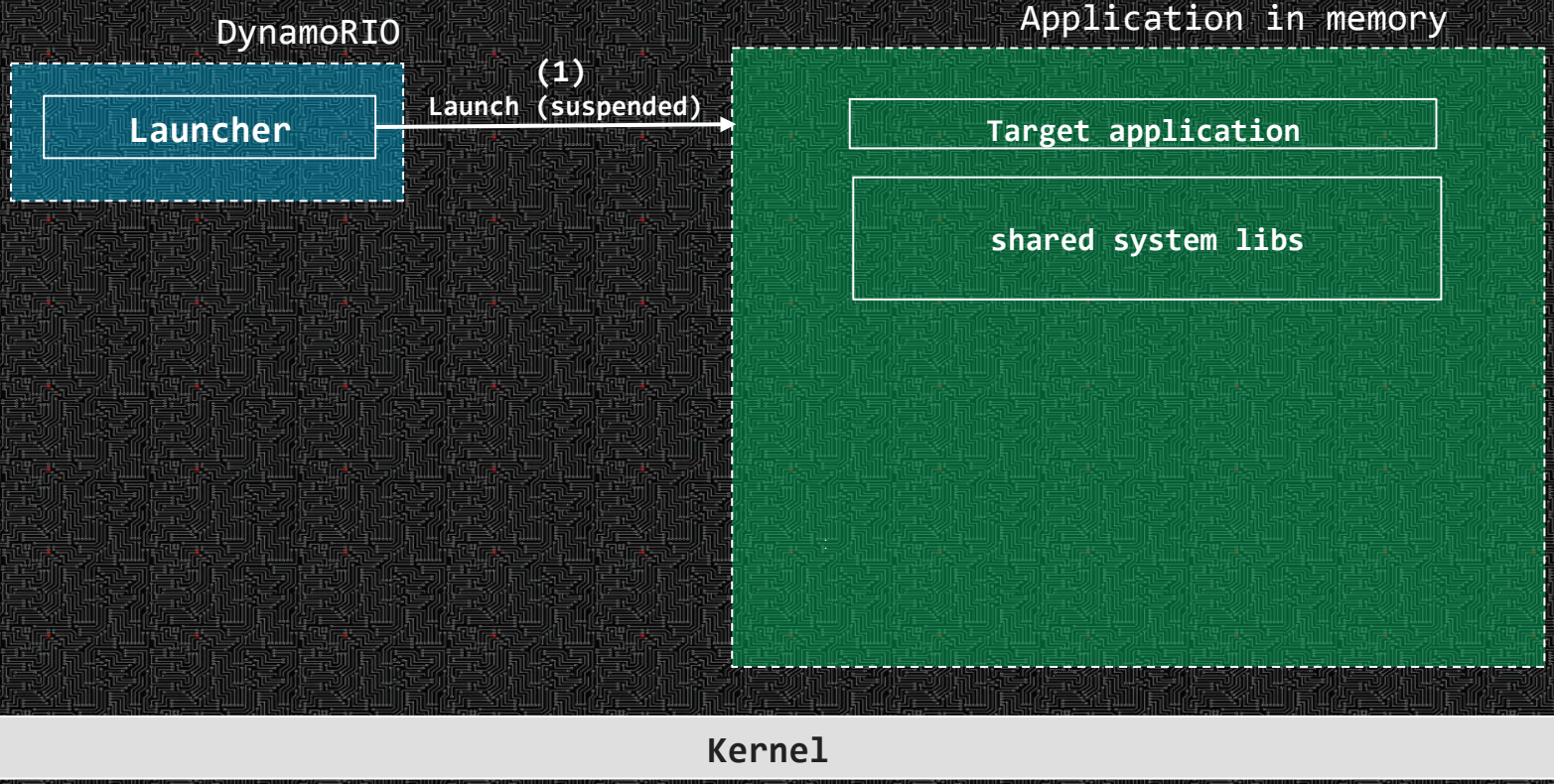
    https://github.com/DynamoRIO/dynamorio

Dynamic Binary Instrumentation (DBI) is a technique of analyzing the behavior of a binary application at runtime through the injection of instrumentation code.

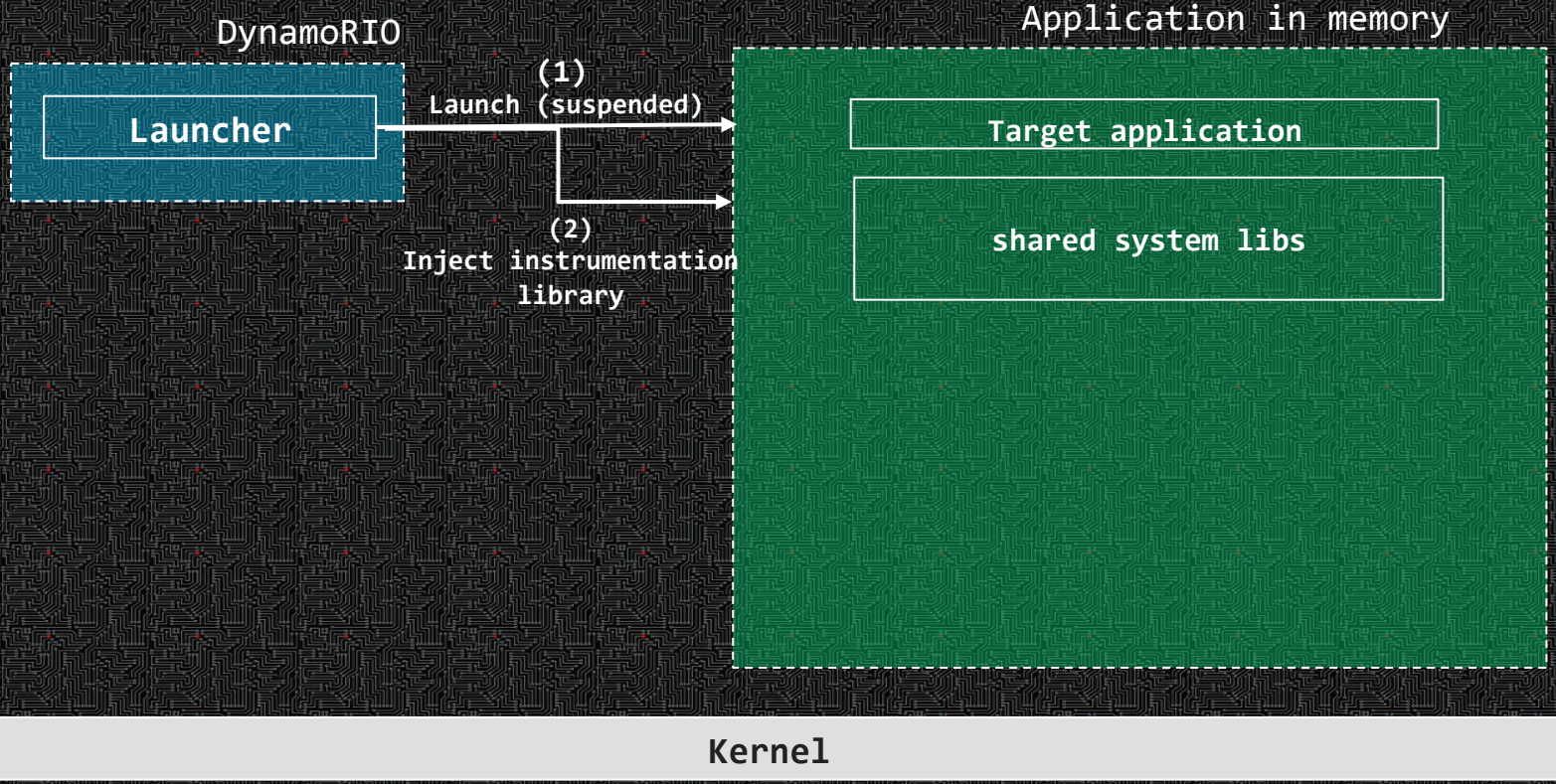
How Does DynamoRIO Work ? (10000 foot view)



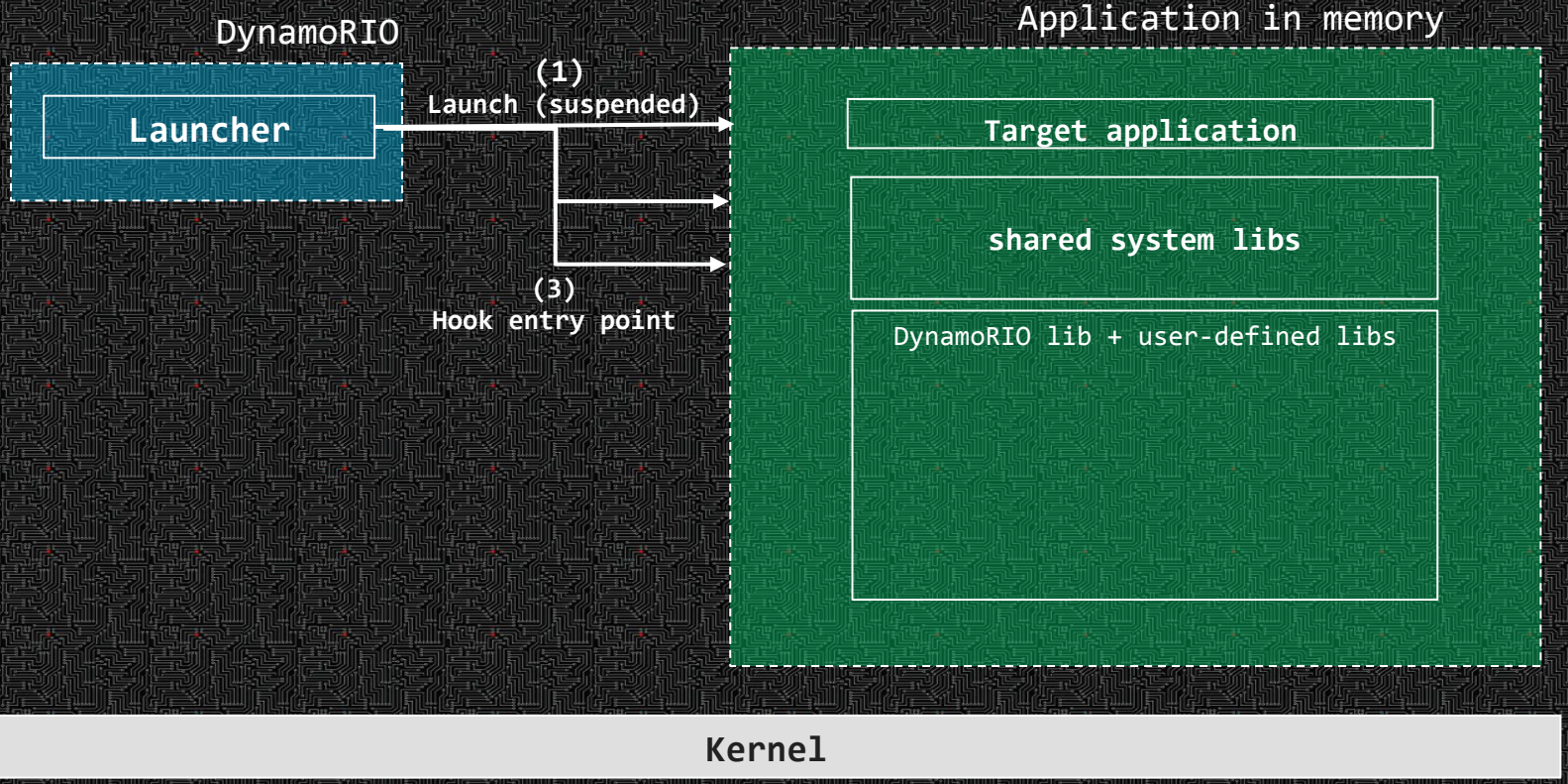
How Does DynamoRIO Work ? (10000 foot view)



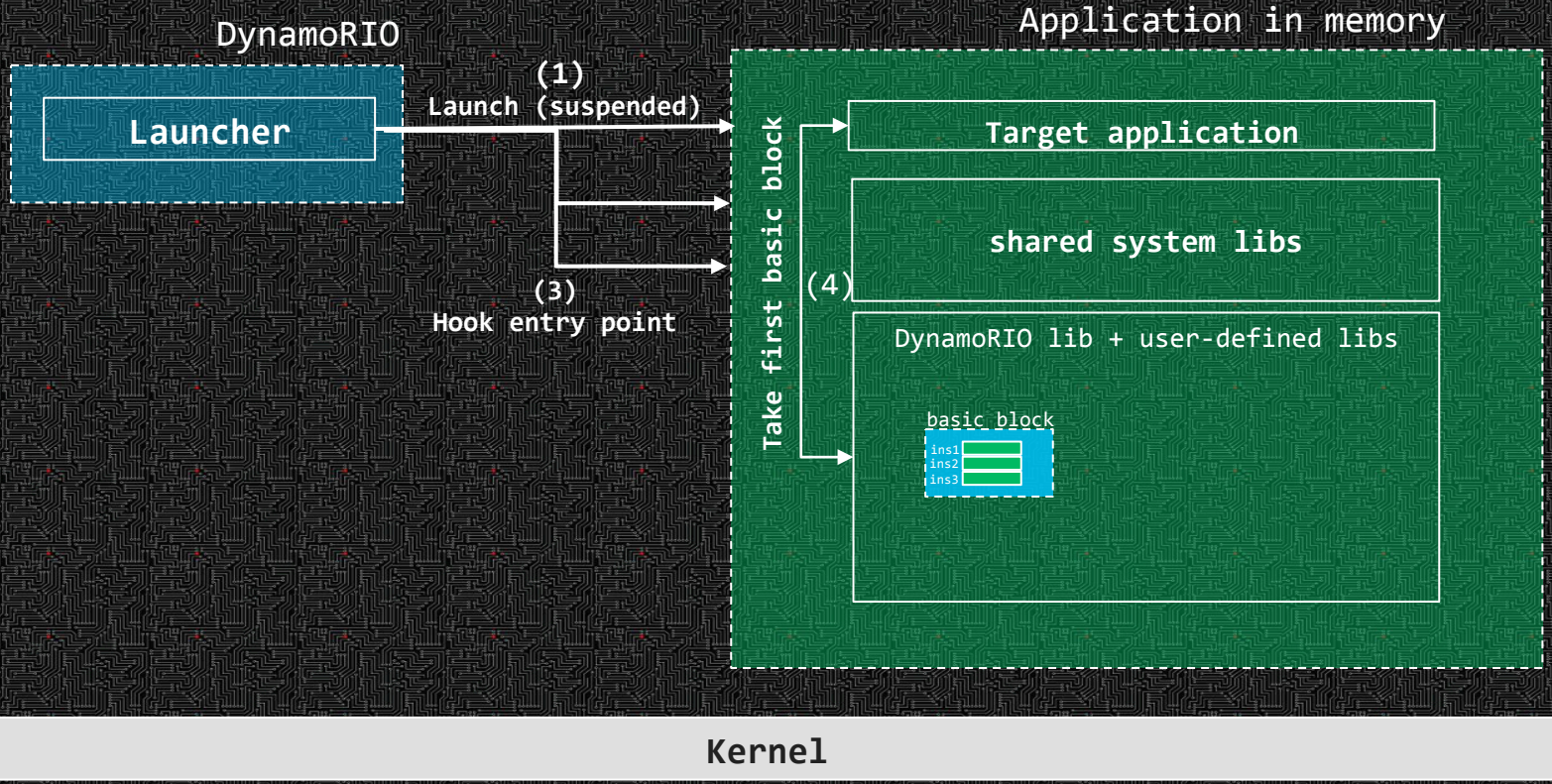
How Does DynamoRIO Work ? (10000 foot view)



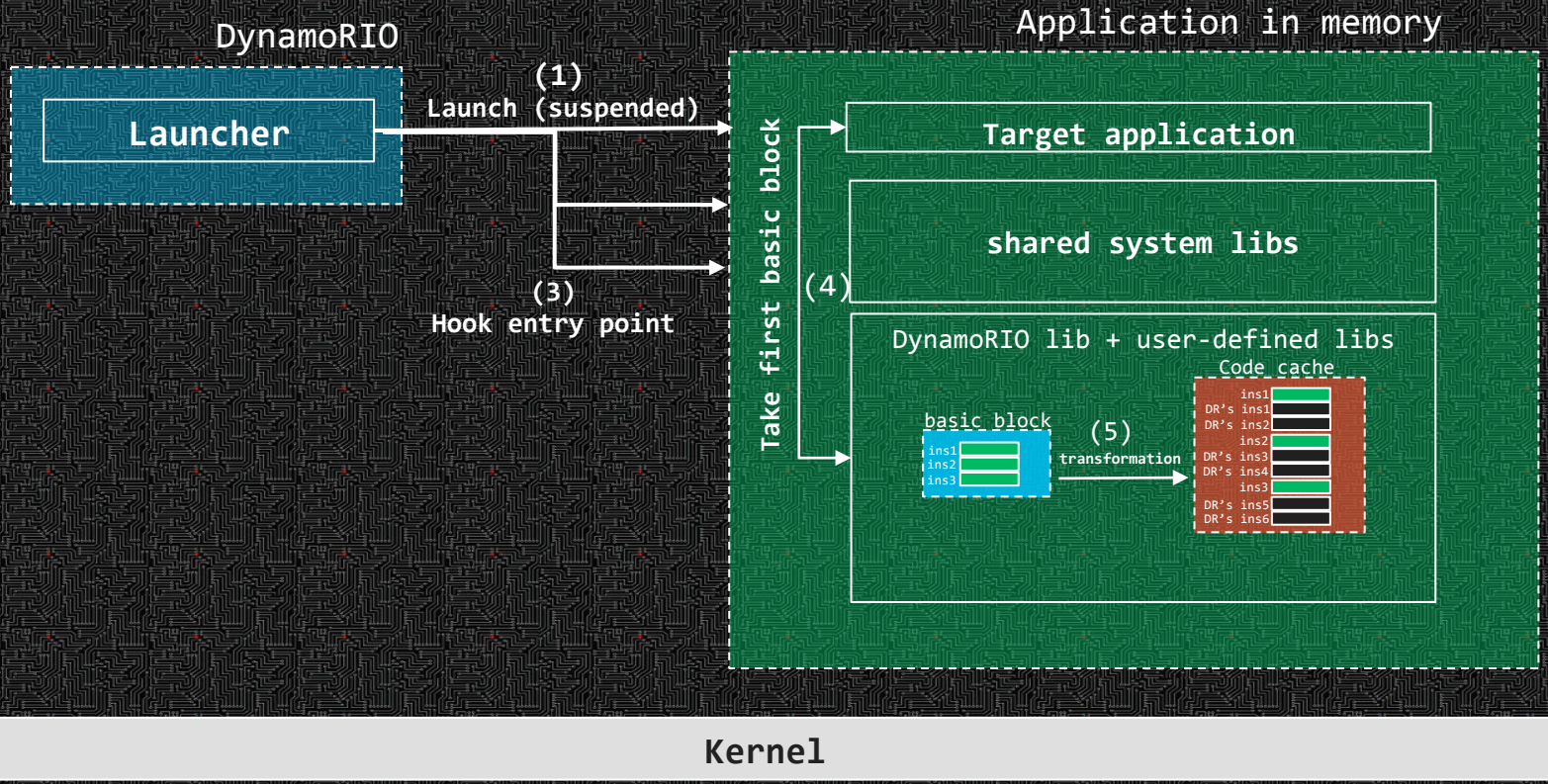
How Does DynamoRIO Work ? (10000 foot view)



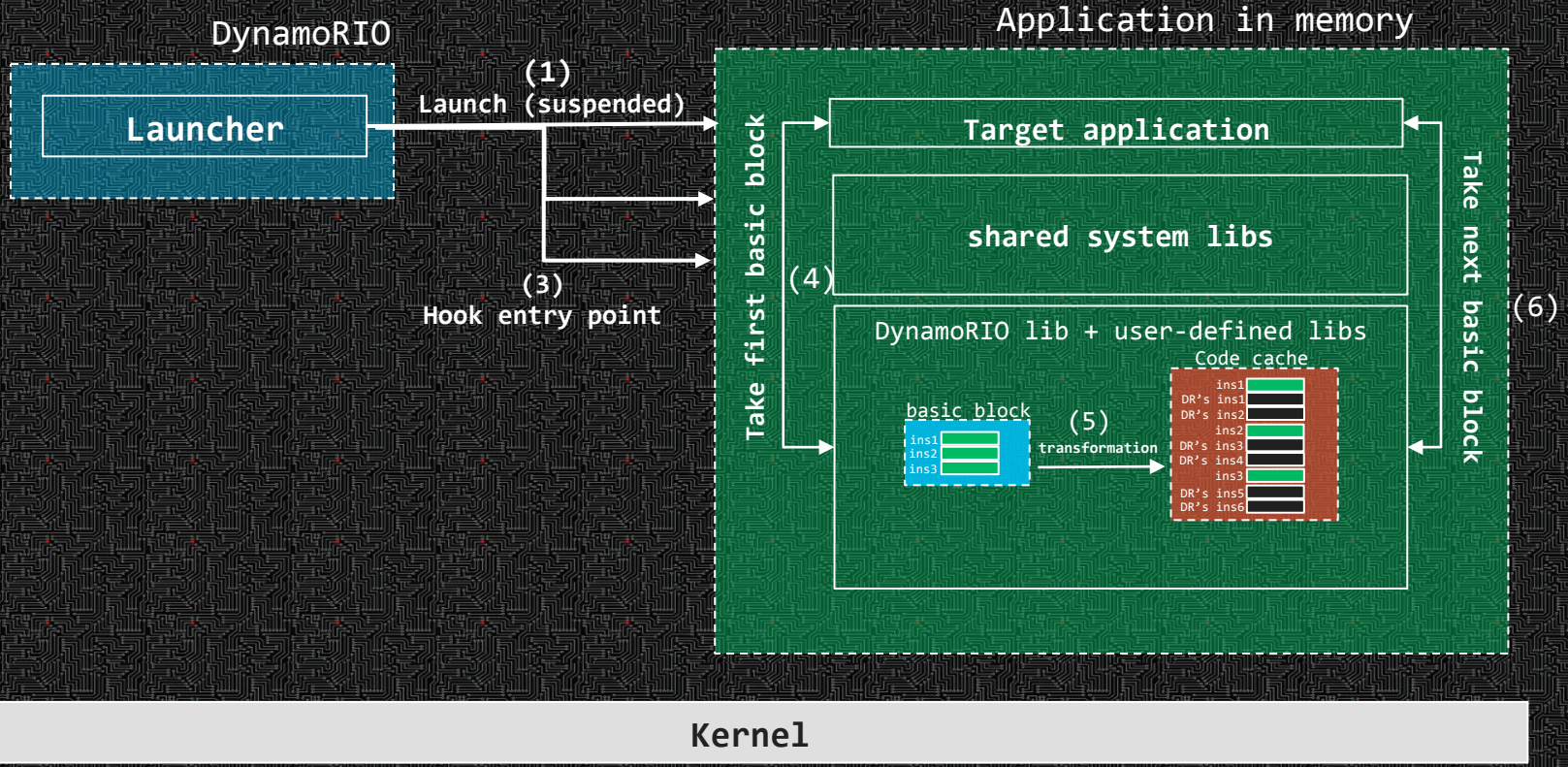
How Does DynamoRIO Work ? (10000 foot view)



How Does DynamoRIO Work ? (10000 foot view)



How Does DynamoRIO Work ? (10000 foot view)



Challenges

- Lack of source code
- Obfuscation
- Encryption

Challenges

- ~~Lack of source code~~ – WinAFL + DynamoRIO
- WinAFL supports only file-based fuzzing
- Obfuscation
- Encryption

WinAFL patch (netAFL)

Fuzzer in memory

AFL fuzzer

Client/server module

User-defined encryption

Malware in memory



Malware (main module)

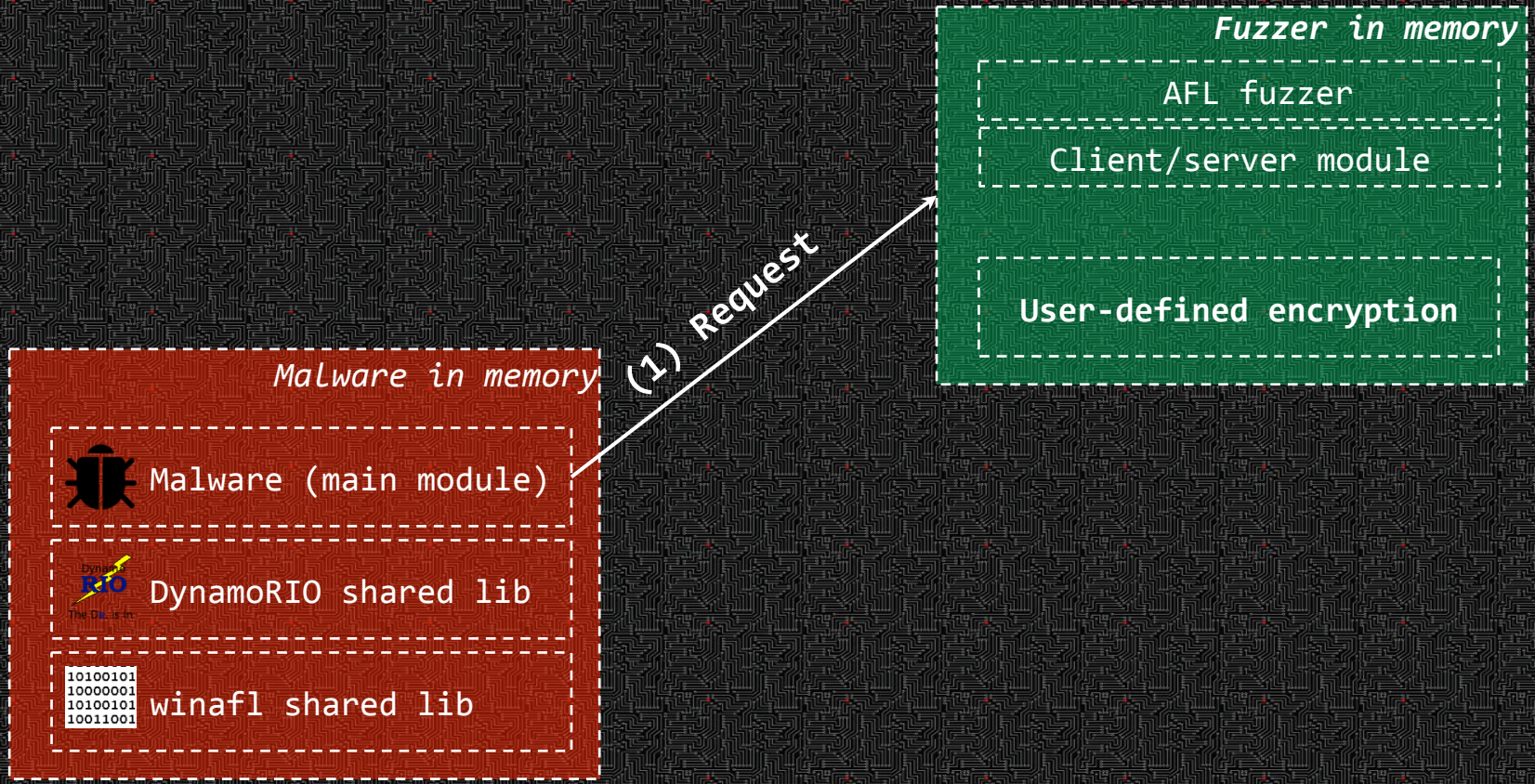


DynamoRIO shared lib

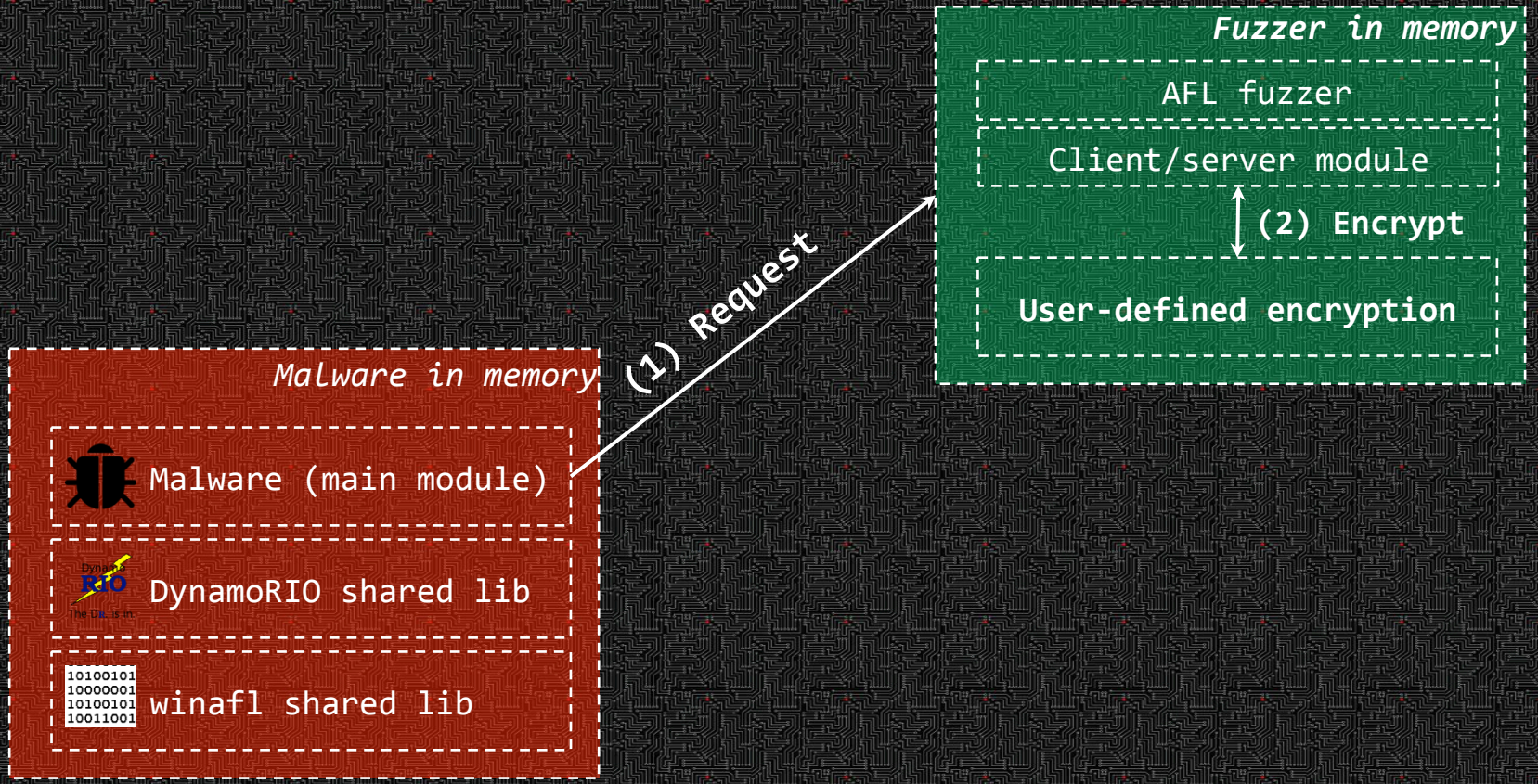


winafl shared lib

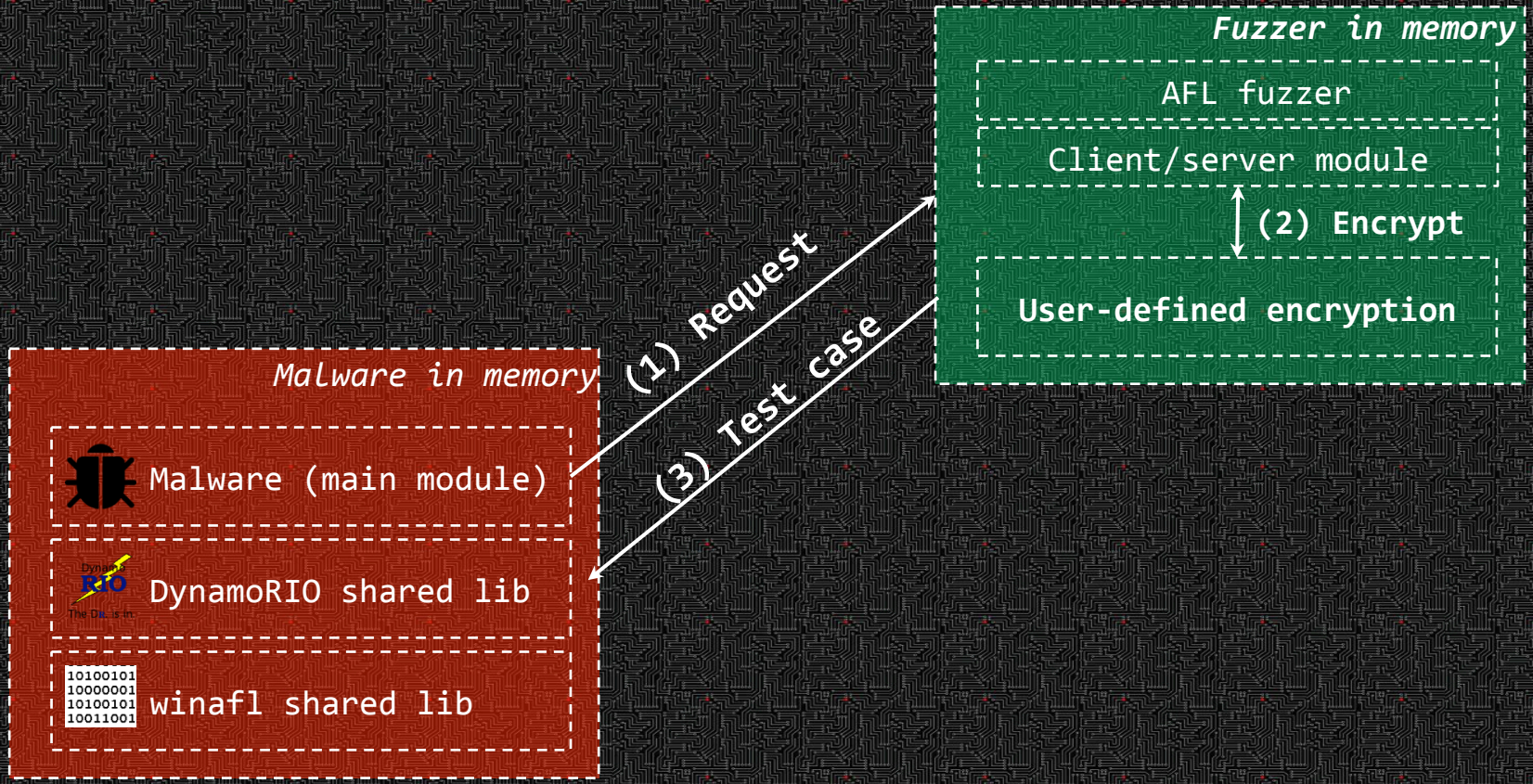
WinAFL patch (netAFL)



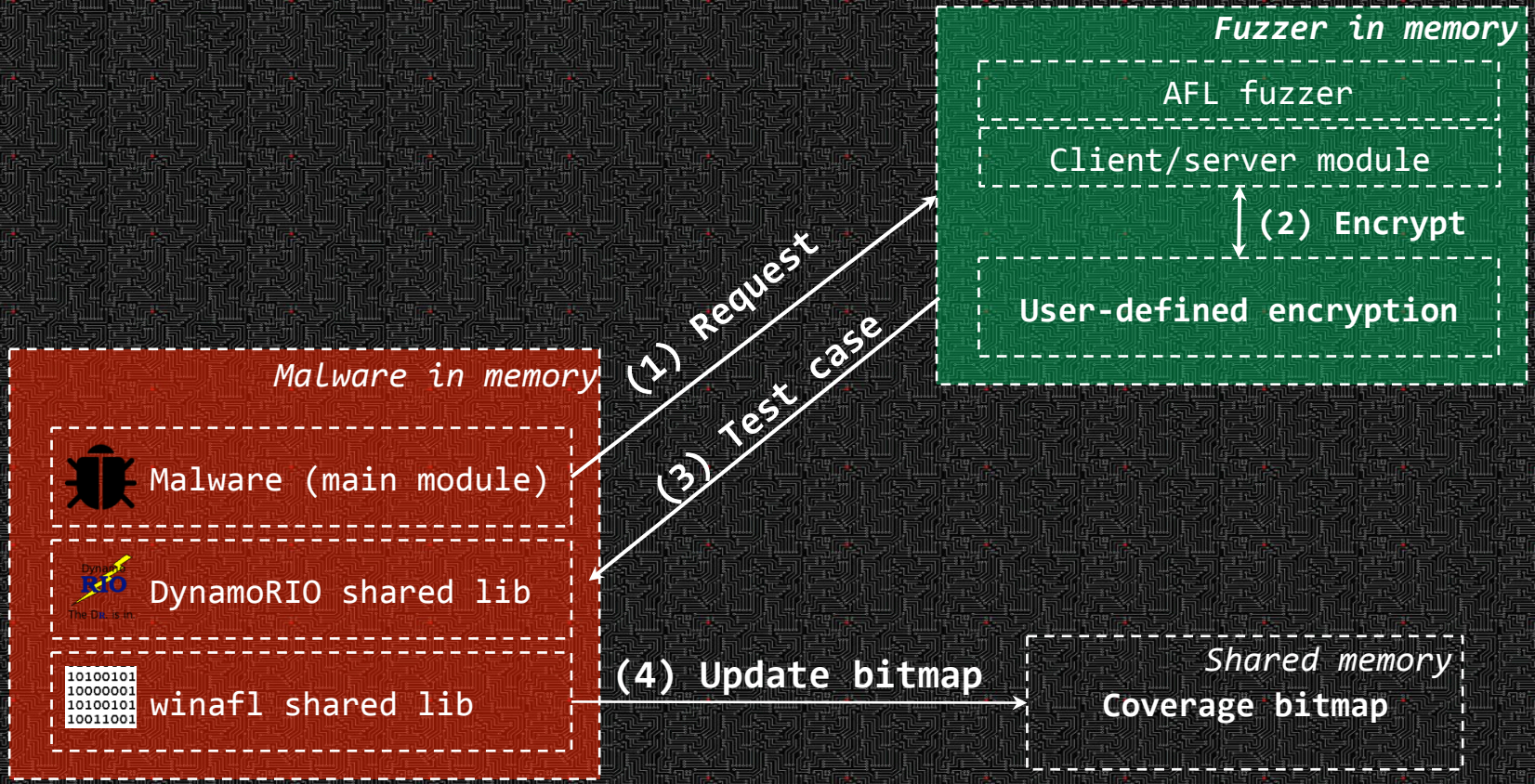
WinAFL patch (netAFL)



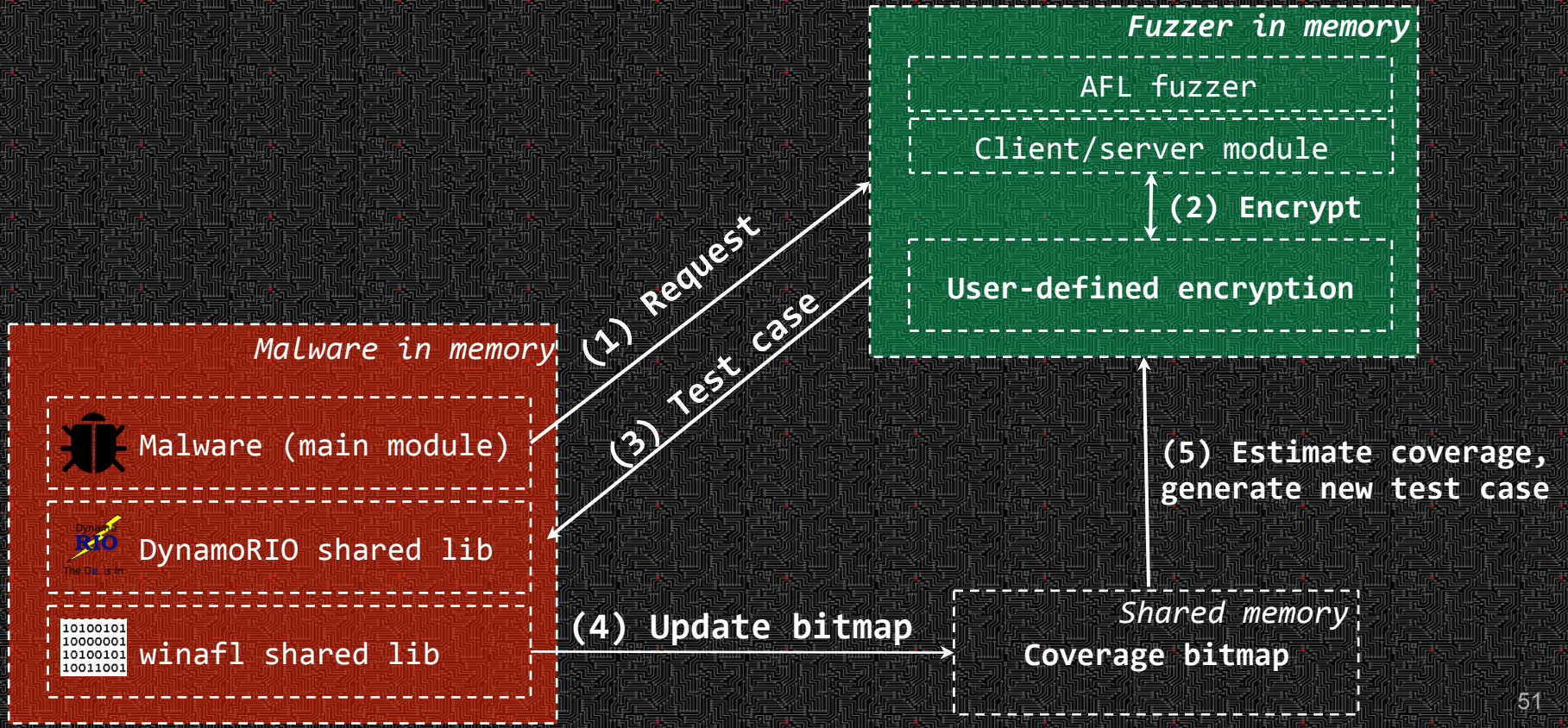
WinAFL patch (netAFL)



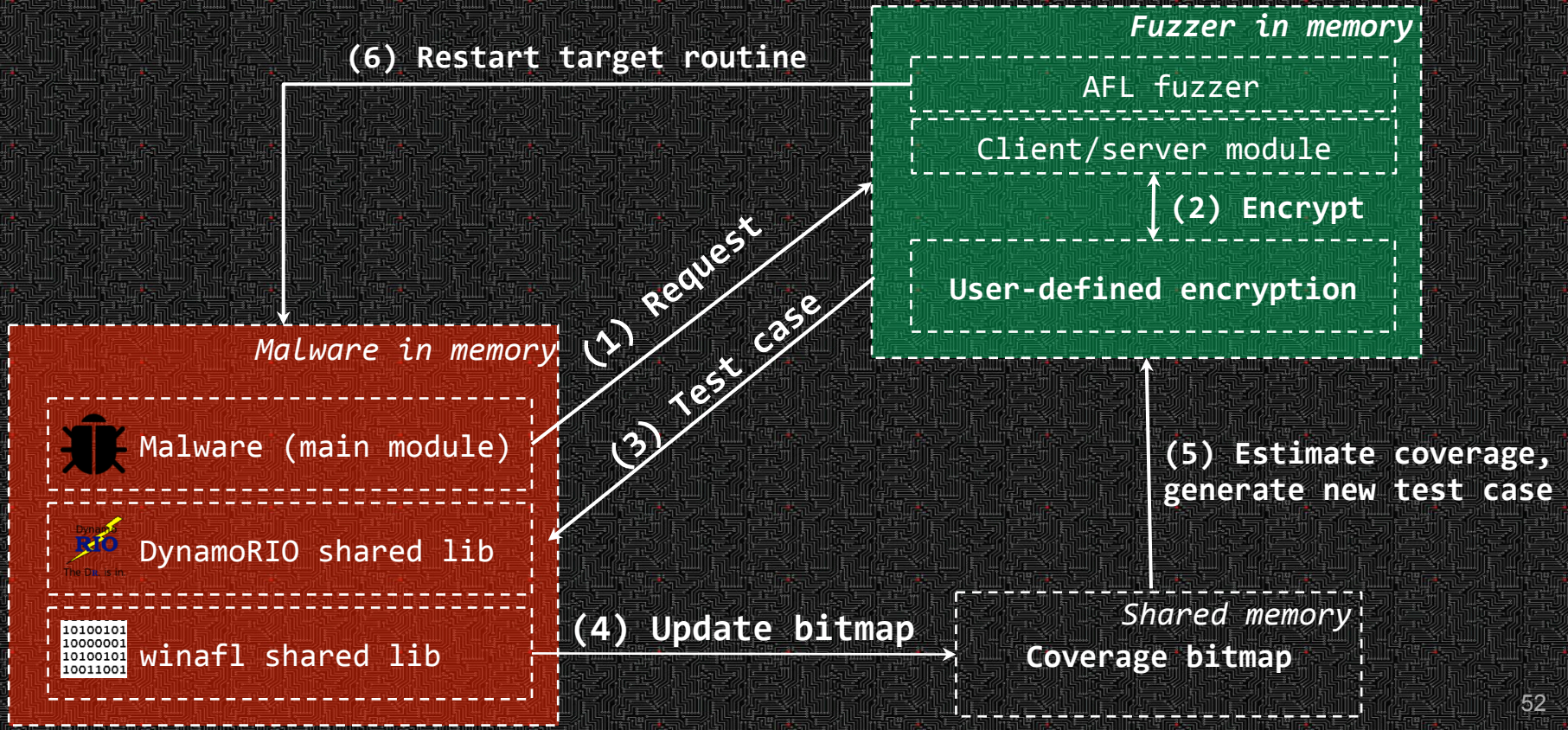
WinAFL patch (netAFL)



WinAFL patch (netAFL)



WinAFL patch (netAFL)



WinAFL patch (netAFL). Usage

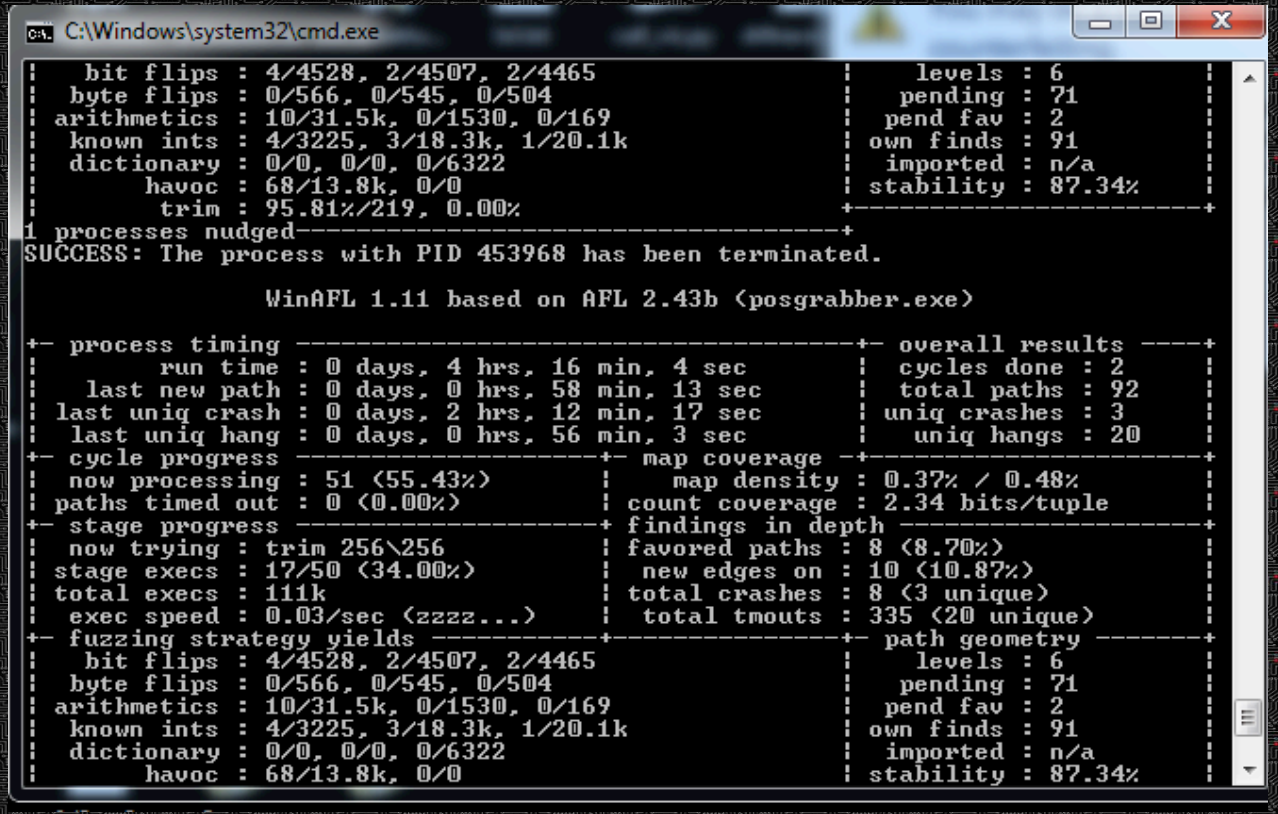
```
> afl-fuzz.exe –usage
Fake server settings:
-s              - Server port to listen for incoming connections

Network fuzzing settings:
-a              - IP address to send data in
-U              - Use UDP (default TCP)
-p              - Port to send data in
-w              - Delay in milliseconds before sending data

User-defined cryptographic library settings:
-L              - Path to library with user-defined crypto
User-defined CnC server settings:
-l              - Path to library with user-defined CnC server
```

WinAFL patch (netAFL). User-defined Encryption & CnC

- Custom encryption function prototypes:
  - *char* APIENTRY encrypt_buffer(char *buf, int buf_size) – to encrypt*
  - *void APIENTRY free_buffer(char *buf) - to free memory used for encrypted data*
- **Custom CnC function prototypes:**
  - *int APIENTRY cnc_init(char *port) - to init CnC*
  - *int APIENTRY cnc_run(char *data) - to send AFL's test case*
- There is an example distributed with winAFL patch (netAFL)

TOOL DEMO

4 hours after



Case Study I. Mirai

未来

Mirai. Overview



Mirai. Overview

- IoT-based botnet DDoS
- Most disruptive DDoS cyber-attack in history
  - 2016 Dyn DDoS (1.2Tb/s).
  - Krebs on Security (620 Gb/s)
  - OVH DDoS (1TB/s)
- Hundreds of thousands devices across 164 countries
- Some elements of SDLC:

```
gcc -lefence -g -DDEBUG -static -lpthread -pthread -O3 src/*.c -o loader.dbg
```

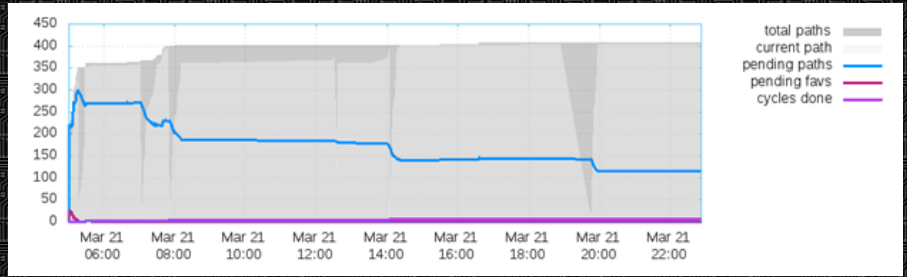
Mirai. HTTP-response parser

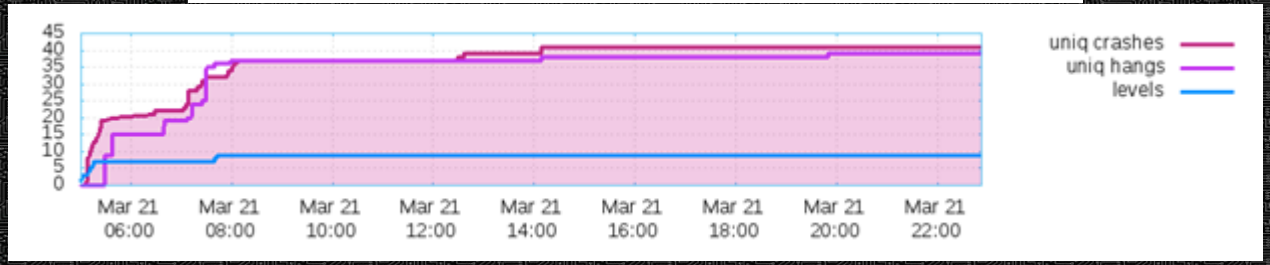
```
375         if (FD_ISSET(conn->fd, &fdset_rd))
376             {
377                 if (conn->state == HTTP_CONN_RECV_HEADER)
378                 {
379                     int processed = 0;
380 
381                     util_zero(generic_memes, 10240);
382                     if ((ret = recv(conn->fd, generic_memes, 10240, MSG_NOSIGNAL | MSG_PEEK)) < 1)
383                     {
384                         close(conn->fd);
385                         conn->fd = -1;
386                         conn->state = HTTP_CONN_INIT;
387                         continue;
388                     }
389 
390 
391                     // we want to process a full http header (^:
392                     if (util_memsearch(generic_memes, ret, "\r\n\r\n", 4) == -1 && ret < 10240)
393                         continue;
```

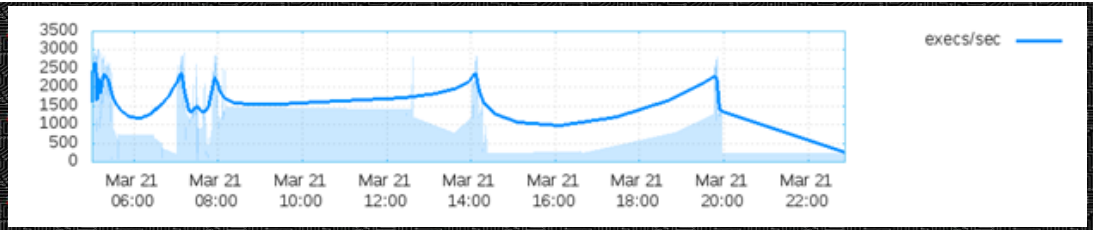
Mirai. Seed File

```
GET / HTTP/1.1
User-Agent: Mozilla/5.0 (Windows NT 10.0; WOW64) AppleWebKit/537.36 (KHTML, like
Gecko) Chrome/51.0.2704.103 Safari/537.36
Host: localhost
Connection: keep-alive
Accept: text/html,application/xhtml+xml,application/xml;q=0.9,image/webp,*/
*;q=0.8
Accept-Language: en-US,en;q=0.8
Content-Type: application/x-www-form-urlencoded
content-length: 3
```

Mirai. Fuzzing Statistics







Mirai. Vulnerability

```
    else if (loc_ptr[0] == '/')
    {
        //handle relative url
        util_zero(conn->path + 1, HTTP_PATH_MAX - 1);
        if (util_strlen(&(loc_ptr[ii + 1])) > 0 && util_strlen(&(loc_ptr[ii + 1])) < HTTP_PATH_MAX)
            util_strcpy(conn->path + 1, &(loc_ptr[ii + 1]));
    }

    conn->state = HTTP_CONN_RESTART;
    continue;
}
```

Mirai. Crash Case

```
GET / HTTP/1.1
User-Agent: Mozilla/5.0 (Wndows NT 10.0; WOW64) AppleWeQKit/537.36
    (KHTML,
like Geckt) Chrome/51.0.2704.103 Safari/537.36
Host: location:/keep-alive
Accept: text/html,application/xhtml+xml,application/xml;q=0.9,imagv/��
,*/*;q=0.8
Accept-Language: =0.8
Content-Type: applicat�n/x-www-form-urlencoded
content-length: 3
LOL
```

Mirai. Exploitation Demo

Case Study II. Dexter v2

Dexter. Overview

- Point-of-sales (PoS) malware which is targeted Microsoft Windows terminals
- Steals credit/debit card details
- First known botnet that targets POS terminals (mostly in US)



Dexter. Target

```
if(HttpSendRequest(hRequest,"Content-Type:application/x-www-form-urlencoded"

    //Build cookie url
    _memset(Url,0x00,sizeof(Url));
    wsprintf(Url,"http://%s%s",Urls[x],Pages[x]);
    ////////////////////////////////

    //Get cookie - commands
    _memset(Commands,0x00,sizeof(Commands));
    if(GetCookie(Url,Commands)==TRUE) { //We are on valid url

        pCommands = Commands;
        pCommands += lstrlen(response);
        //MessageBox(NULL,pCommands,"Check if valid",MB_OK);
        if(*pCommands=='$') { //This seems to be real command

            ExecCommands(pCommands);
            ValidIndex = TRUE;
            AlreadyConnected = TRUE;
            PresistInfo = FALSE;
        } else { ValidIndex = FALSE; }
    } else { ValidIndex = FALSE; }
}
```

```
void ExecCommands(char *pCommands) {

    char Url[255],val[5];
    DWORD dVal;


    pCommands++; //skip '$'
    ///MessageBox(NULL,pCommands,NULL,MB_OK);
    while(*pCommands!='#' && lstrlen(pCommands)) {

    if(StrCmpNI(pCommands,update,lstrlen(update))==0) {

        pCommands += lstrlen(update);
        CopyTill(Url,pCommands,';');
        lstrcat(Url,varKey);
        lstrcat(Url,Key);
        Update(Url);
    } else
    if(StrCmpNI(pCommands,checkin,lstrlen(checkin))==0) {

        pCommands += lstrlen(checkin);
        pCommands += CopyTill(val,pCommands,';');
        pCommands += 1;
```

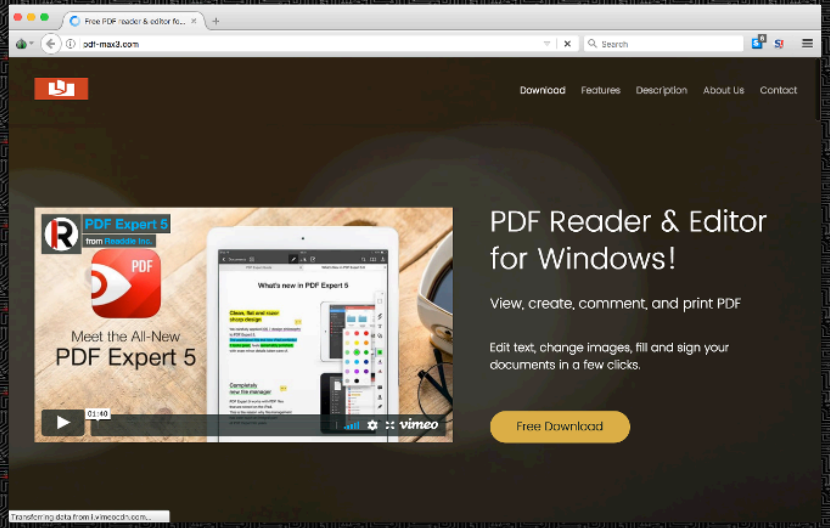
Dexter. Vulnerability

```
void ExecCommands(char *pCommands) {

    char Url[255],val[5];
    DWORD dVal;


    pCommands++; //skip '$'
    ///MessageBox(NULL,pCommands,NULL,MB_OK);
    while(*pCommands!='#' && lstrlen(pCommands)) {

    if(StrCmpNI(pCommands,update,lstrlen(update))==0) {

        pCommands += lstrlen(update);
        CopyTill(Url,pCommands,';');
        lstrcat(Url,varKey);
        lstrcat(Url,Key);
        Update(Url);
    } else
    if(StrCmpNI(pCommands,checkin,lstrlen(checkin))==0) {

        pCommands += lstrlen(checkin);
        pCommands += CopyTill(val,pCommands,';');
        pCommands += 1;
```

Case Study III. TinyNuke

TinyNuke. Overview

- Man-in-the-browser Trojan equipped with common features: WebInjects, SOCKS, Proxy, JSON parsers and etc.
- Distributed over trojanized PDF Reader



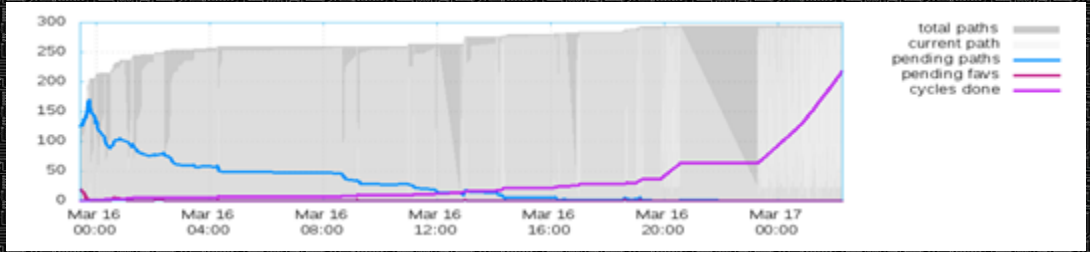
TinyNuke. Target

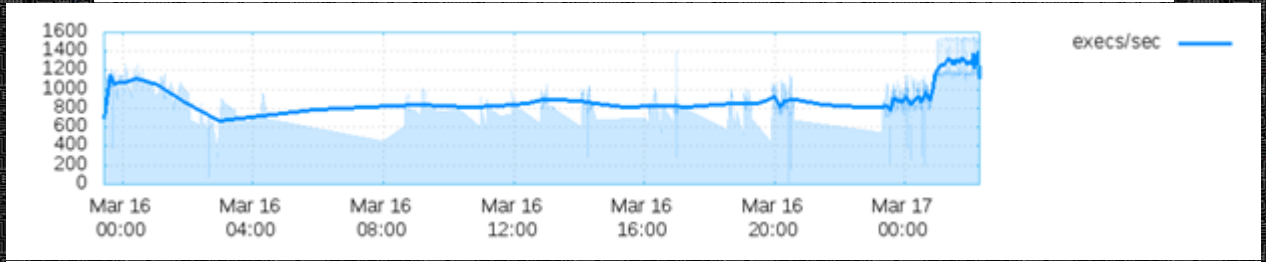
```
void LoadWebInjects()
{
    if(loaded)
        return;
    char  request[32] = { 0 };
    Funcs::pLstrcpyA(request, Strs::injectsRequest);
    char *jsonStr = PanelRequest(request, NULL);
    if(!(json = AiJsonParse(jsonStr)))
        goto err;
    if(json->error != AI_JSON_E_OK)
        goto err;
    if(json->root.type != AI_JSON_OBJECT)
        goto err;
    loaded = TRUE;
    return;
err:
    Funcs::pFree(jsonStr);
    AiJsonDestroy(json);
    Funcs::pSleep(POLL);
    LoadWebInjects();
}
```

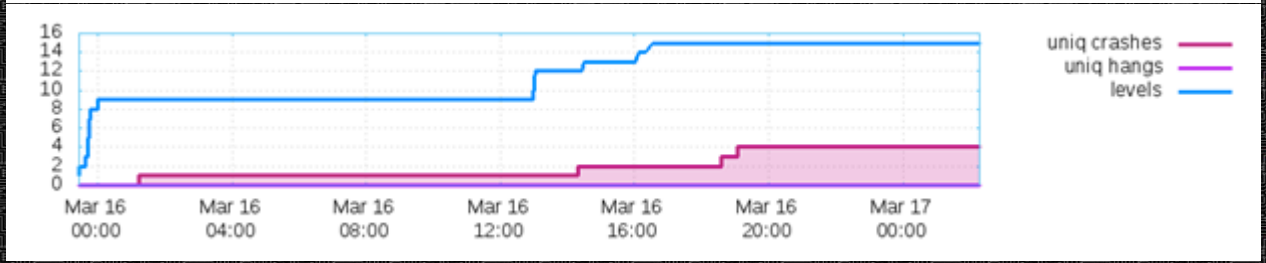
TinyNuke. Seed File

```
{
    "expand" : "attributes",
    "link" : {
                "rel" : "self",
                "href" : "http://localhost:8095/crowd/rest/usermanagement/1/user?username=my_username"
    },
    "name" : "my_username",
    "first-name" : "My",
    "last-name" : "Username",
    "display-name" : "My Username",
    "email" : "user@example.test",
    "password" : {
                "link" : {
                "rel" : "edit",
                "href" : "http://localhost:8095/crowd/rest/usermanagement/1/user/password?username=my_username"
                }
    },
    "active" : true,
    "attributes" : {
                "link" : {
                "rel" : "self",
                "href" : "http://localhost:8095/crowd/rest/usermanagement/1/user/attribute?username=my_username"
                },
                "attributes" : []
    }
}
```

TinyNuke. Statistics



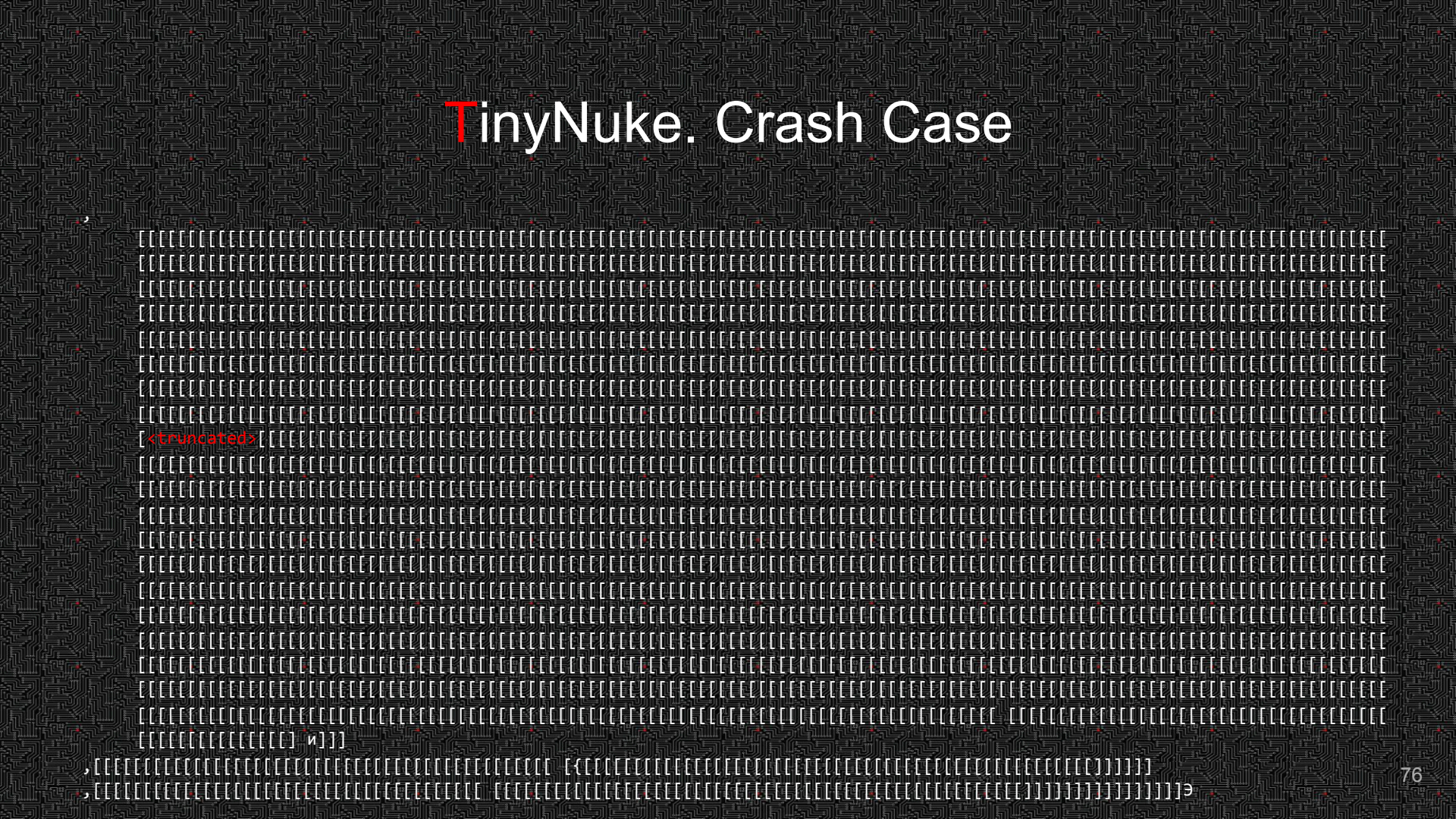




TinyNuke. Vulnerability

```
364  AiJsonError ParseValue(AiJson *json, char **str, AiJsonValue *value)
365  {
366      AiJsonError err;
367      switch(**str)
368      {
369          case CHAR_STR_OPEN_CLOSE:
370          {
379          case CHAR_OBJECT_OPEN:
380          {
390          case CHAR_ARRAY_OPEN:
391          {
392              value->type = AI_JSON_ARRAY;
393              value->data.array = JsonListCreate(json);
394              if(!value->data.array)
395                  return AI_JSON_E_ALLOC;
396              err = ParseArray(json, str, value->data.array);
397              if(err != AI_JSON_E_OK)
398                  return err;
399              break;
400          }
```

TinyNuke. Crash Case



Case Study IV. KINS

KINS. Overview

- Banking trojan implemented on top of Zeus source code
- Used to attack major financial institution in Germany and Netherlands
- Contains rootkit module, HTTP-protocol parser and Web-injection capabilities

KINS. Seed File

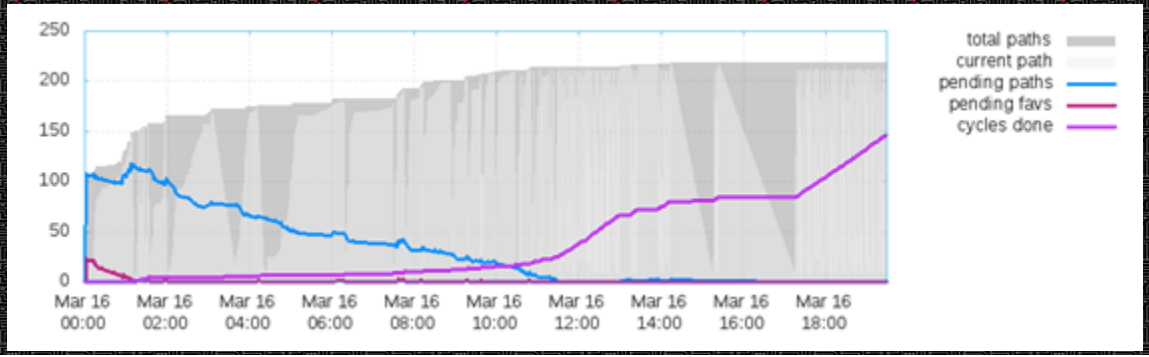
HTTP/1.1 200 OK
Date: Sun, 18 Oct 2009 08:56:53 GMT
Server: Apache/2.2.14 (Win32)
Transfer-Encoding: chunked
Last-Modified: Sat, 20 Nov 2004 07:16:26 GMT
ETag: "10000000565a5-2c-3e94b66c2e680"
Accept-Ranges: bytes
Content-Length:44
Connection: close
Content-Type: text/html
X-Pad: avoid browser bug

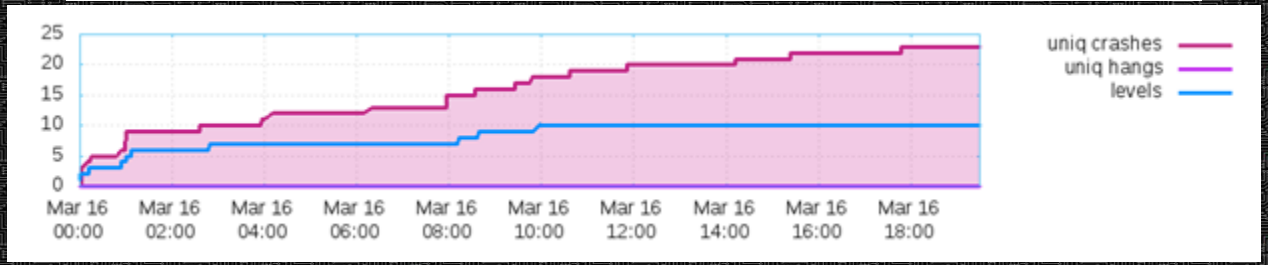
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
<html><body><h1>It works!</h1></body></html>

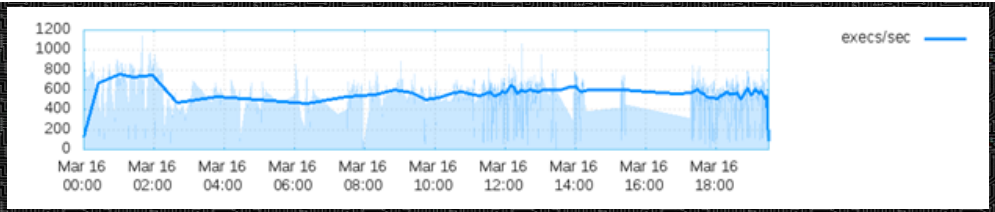
KINS. Target

```
            // Copy to our buffer
            // nc->response = HTTP-Header + Binary data
            if(readed > 0)
            {
                Mem::_copy(nc->response + nc->responseSize, buf, readed);
                nc->responseSize += readed;
#               if defined WDEBUG1
                WDEBUG1(WDDT_INFO, "nc->responseSize=%u", nc->responseSize);
#               endif
            }

            if((analizeResult = analizeHttpResponse(&info, nc->response, nc->responseSize)) == 1 &&
                (analizeResult = analizeHttpResponseBody(&info, nc->response, nc->responseSize, (readed == 0), &captchaData, &captchaSize)) == 1)
            {
#               if defined WDEBUG1
                WDEBUG1(WDDT_INFO, "Read whole captcha, size: %d", captchaSize);
#               endif

                WCHAR file[MAX_PATH];
                file[0] = 0;
                DWORD tmp;
                CSTR_GETW(decodedString, captcha_filename_format);
```

KINS. Statistics







KINS. Vulnerability

```
//Content-Length
if((header = HttpTools::_getMimeHeader(request, requestSize, "Content-Length", &headerSize)) != NULL)
{
    LPSTR tmp = Str::_CopyExA(header, headerSize);
    bool bad = (tmp == NULL || (info->contentLength = (DWORD)Str::_ToInt64A(tmp, NULL)) < 0);
    Mem::free(tmp);
    info->flags |= HRIF_DEFINED_LENGTH;
    if(bad)
    {
```

```
LPSTR HttpTools::_getMimeHeader(const void *mimeData, DWORD mimeSize, const LPSTR header, DWORD *size)
{
    SIZE_T headerSize = ((DWORD_PTR)header > GMH_COUNT ? Str::_LengthA(header) : 0);
    LPSTR data        = (LPSTR)mimeData;
    LPSTR dataEnd     = data + mimeSize;


        else if(curSize > headerSize && CWA(shlwapi, StrCmpNIA)(header, cur, headerSize) == 0 && cur[headerSize] == ':')
        {
            dataEnd = cur + curSize;
            cur     = cur + headerSize + 1;

            while(IS_SPACE_CHAR(*cur))
                cur++;
            *size = (DWORD)(dataEnd - cur);
            return cur;
        }
    }
```

KINS. Vulnerability

```
void *Mem::alloc(SIZE_T size)
{
  register void *p;

  if(size == 0)p = NULL;
  else
  {
#   if(MEM_ALLOC_SAFE_BYTES == 1)
    size += ADVANCED_ALLOC_BYTES;
#   endif

    p = CWA(kernel32, HeapAlloc)(mainHeap, HEAP_ZERO_MEMORY, size);
  }
  return p;
}
```

```
LPSTR Str::_CopyExA(LPSTR pstrSource, int iSize, bool putNull)
{
  if(pstrSource == NULL)return NULL;
  if(iSize == -1)iSize = _LengthA(pstrSource);
  LPSTR p = (LPSTR)Mem::alloc(iSize + 1);
  if(p != NULL)
  {
    Mem::_copy(p, pstrSource, iSize);
    if(putNull) p[iSize] = 0;
  }
  return p;
}
```

KINS. Crash Case

```
HTTP/1.1 200 OK
Date: Sun, 18 Oct 2009 08:56:53 GMT
Server: Ap32)
Transfer-Encoding: chunked
Lasdified: Sat, 20 Nov 2004 07:16:26 GMT
ETag: "10000000565a5-2c-3e94b66c2e680"
Accept-Ranges: bytes
Content-Length:

Connection: close
Content-Type: text/html
X-Pad: avoid browser bug

AAAAAAAAy><h1>It works!</h1></body></html>
```

Challenges and Issues

- Preliminary reverse engineering required
- Need to find/trigger target function
- Bugs in DynamoRIO/WinAFL
- Seed file selection
- Traffic encryption
- Stability

Drltrace

- Drltrace is an open-source API calls tracer for Windows (similar to ltrace for Linux).

drltrace.exe -logdir . -print_ret_addr – malware.exe

```
234369  ~~2840~~ WINHTTP.dll!WinHttpConnect
234370      arg 0: 0x003ca440 (type=<unknown>, size=0x0)
234371      arg 1: susiku.info (type=wchar_t*, size=0x0)
234372      arg 2: 0x00000050 (type=<unknown>, size=0x0)
234373      arg 3: 0x0 (type=DWORD, size=0x4)
234553  ~~2840~~ WINHTTP.dll!WinHttpOpenRequest
234554      arg 0: 0x004173a0 (type=<unknown>, size=0x0)
234555      arg 1: GET (type=wchar_t*, size=0x0)
234556      arg 2: /rbody320 (type=wchar_t*, size=0x0)
234557      arg 3: <null> (type=wchar_t*, size=0x0)
234558      arg 4: <null> (type=wchar_t*, size=0x0)
234559      arg 5: <null> (type=wchar_t*, size=0x0)
```

https://github.com/mxmssh/drltrace

Future Work

- Automatically find target function
- Increase stability
- Code-coverage visualization

Conclusion

- Bugs in malware exist and can be used to defend against them
- Coverage-guided fuzzing was able to find bugs in each malware selected for experiment within 24 hours
- Two bugs lead to RCE, one bug can be used to defend against DDoS
- This technique can also be used to find bugs in network-based applications (probably most useful application)

Thank you!

https://github.com/mxmssh/netafl

https://github.com/mxmssh

https://www.linkedin.com/in/mshudrak