A CRITICAL ANALYSIS OF DROPBOX SOFTWARE SECURITY

Florian LEDOUX
florian.ledoux(at)eads.net
@Myst3rie

Nicolas RUFF
nicolas.ruff(at)eads.net
@newsoft

EADS Innovation Works
SE/IT department
Suresnes, FRANCE

DROPBOX OVERVIEW

Dropbox: a leader in Cloud backup

- Over 50 million users
- Estimated company value: over $1 billion
- (Year: 2011 / Source: Wikipedia)

Client software available for

- Windows, OS X, Linux, Android, iOS and web browser

Lot of competitors

- Google Drive, SkyDrive, iCloud, box.com ...

DROPBOX OVERVIEW

Dropbox security record (partial)

- March 2011: Dropbox client for Smartphones do not make use of SSL/TLS encryption
- April 2011: Derek Newton realized that login/password is useless (if you happen to know host_id secret)
- June 2011: a software upgrade issue provided password-free access to all user accounts for one day
- USENIX 2011: "Dark Clouds on the Horizon“
- August 2012: a stolen password from Dropbox employee lead to massive spam

DROPBOX OVERVIEW

Why studying Dropbox ?

- Dropbox is a leader
- No previous work on the effective implementation
- "LAN Sync" protocol routinely observed during penetration testing assignments
- We are happy Dropbox users too ☺

DROPBOX OVERVIEW

Further analysis holds true for client versions 1.1.x to 1.5.x

Windows, Linux and OS X clients are mostly written in Python

- "How Dropbox Did It and How Python Helped" (PyCon 2011)

Windows client

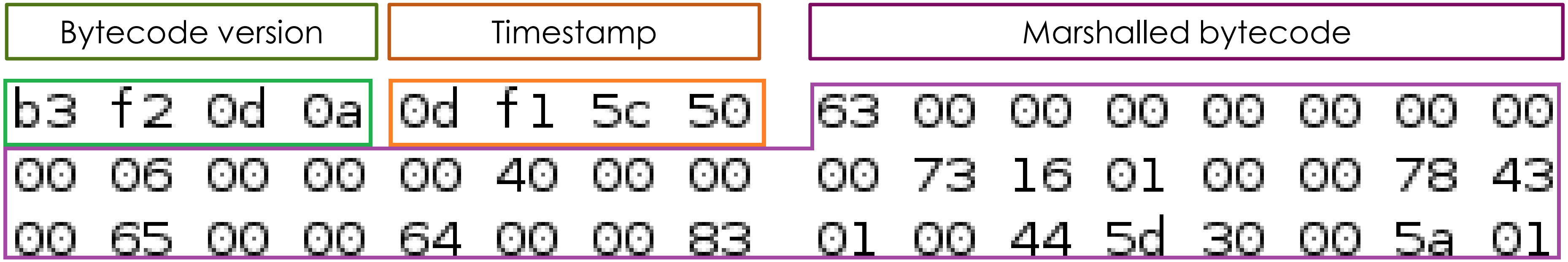
- Generated using PY2EXE
- A ZIP with all PYC files to be found within PE resources
- Python 2.5 interpreter has been slightly customized

Source quest

SOURCE QUEST

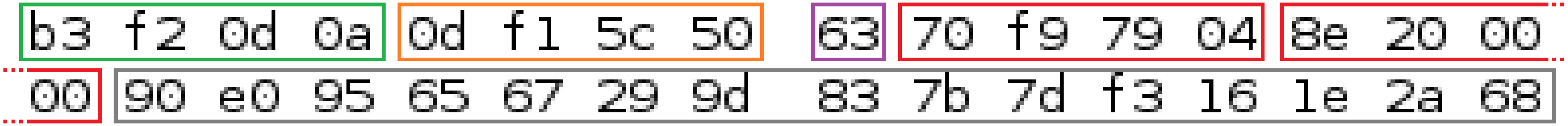
Standard PYC (redux)

- PYC is Python bytecode
- PYO is Python optimized bytecode



```
b3 f2 0d 0a 0d f1 5c 50 63 00 00 00 00 00 00 00
00 06 00 00 00 40 00 00 00 73 16 01 00 00 78 43
00 65 00 00 64 00 00 83 01 00 44 5d 30 00 5a 01
```

Dropbox PYC



```
b3 f2 0d 0a 0d f1 5c 50 63 70 f9 79 04 8e 20 00
00 90 e0 95 65 67 29 9d 83 7b 7d f3 16 1e 2a 68
```

SOURCE QUEST

Diffing **PYTHON25.DLL** with original

- 53 modified functions (out of ~4500)
- Opcodes have been swapped in **PyEval_EvalFrame()**
- Decryption function added in **ReadObjectFromString()**

Which encryption algorithm is used ?

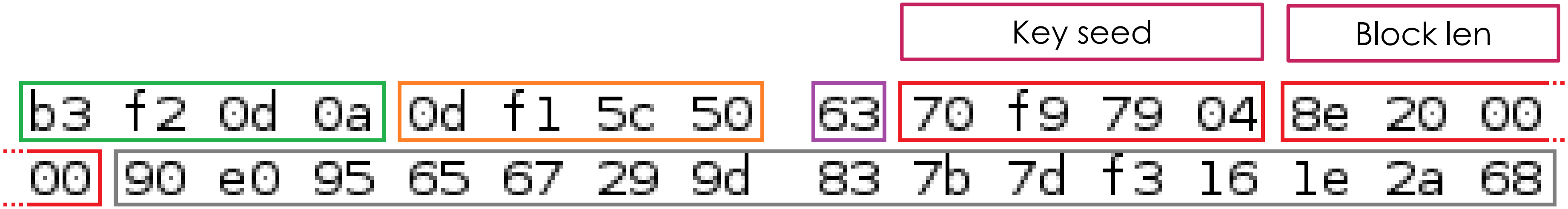
- **0x9e3779b9** constant is linked to TEA symmetric encryption family

  Here: **XXTEA**
- **MT_getnext()** / **MT_decrypt()** functions are involved

SOURCE QUEST

XXTEA implementation

```
void btea(char *data, uint32 len, uint32 const key[4])
```



Key seed

Block len

```
b3 f2 0d 0a 0d f1 5c 50  63 70 f9 79 04 8e 20 00
00 90 e0 95 65 67 29 9d  83 7b 7d f3 16 1e 2a 68
```

ReadObjectFromString()

- Read 1st byte (e.g. **0x63** = code)
- 1st DWORD (e.g. **0x0479F970**) used for key generation
- 2nd DWORD (e.g. **0x208e**) gives block size

Not as easy as it may sounds

Spurious NULL bytes all over the place

SOURCE QUEST

Bytecode decompilation

- Pyretic / unpyc
  - Targets **Python 2.5** (Fails in real life)
- Uncompyle2
  - Targets **Python 2.7** only (Works in real life)

Our solution

- Uncompyle2 fork
- Bytecode translator 2.5 & 2.6 ▶ 2.7
- Single decompilation engine
- Kudos to Eloi Vanderbeken

https://github.com/Mysterie/uncompyle2

CODE INJECTION (BONUS)

PYTHON25.DLL is not easy to reach

- Anonymously mapped in memory
- Not easy to locate import / export tables
- Some functions like **PyRun_File()** are nop'ed

Yet …

- **PyRunString()** is not patched
- Arbitrary Python statements can be run in Dropbox context ☺

DEBUG MODE

- Debugging is hard
- **DBDEV** environment variable to the rescue

Dropbox <= 1.1

```
def is_valid_time_limited_cookie(cookie):
  t_when = int(cookie[:8], 16) ^ 1686035233
  if abs(time.time() - t_when) < 172800:
    if md5.new(cookie[:8] +
'traceme').hexdigest()[:6] == cookie[8:]:
      return True
```

DEBUG MODE

Dropbox ≥ 1.2

```
IS_DEV_MAGIC = DBDEV and
hashlib.md5(DBDEV).hexdigest().startswith('c3da6009e4')
```

DEBUG MODE

DBTRACE can help, too

```
10.224 | MainThread: Dropbox-win-1.1.45 (2796) starting

10.865 | MainThread:  u'host_id' = u'ab75c...

13.509 | MainThread: Opened Dropbox key

32.356 | RTRACE: Sending trace 1327936014
(C:\...\Dropbox\l\4f26b5fc)

33.058 | STATUS: Creating named pipe

59.318 | UPLOAD_HASH: Next needed hash:
AUCwQ6iYIfVxGs1f6HjkWZgqcbmWZiTCs6HU8HRykzU
```

DEBUG MODE

… and many others

- **DBMEMPROF**, **DBCPUPROFILE**, **DBPROFILE**
- **FAKE_BLOCK**
- **DROPBOX_HOST**

Who's in charge here?

- host = 'tarak.corp.dropbox.com'
- Not exposed on the Internet ☺

GIMME RESULTS …

… not excuses !

CONFIGURATION DATABASE

SQLite 3 database: **config.dbx**

- Dropbox < 1.2: easy to dump
- Dropbox ≥ 1.2: "encrypted" SQLite

Encryption

Not: http://sqlcipher.net/

But: http://www.hwaci.com/sw/sqlite/see.html

Activation password == license key == default value ☺

Namely: **7bb07b8d471d642e**

CONFIGURATION DATABASE

Encryption key is machine-protected

Windows

- Seed stored in `HKCU\Software\Dropbox\ks\Client`
- DPAPI encryption

Linux

- Seed stored in `~/.dropbox/hostkeys`
- Custom "obfuscator" (reversible encryption)

Mac OS X

- Seed stored in `~/.dropbox/hostkeys`
- Custom "obfuscator" based on `IOPlatformSerialNumber`, `DAVolumeUUID` and more
- Kudos to the Mac OS X developer for full API re-implementation!

CONFIGURATION DATABASE

Effective encryption key is `PBKDF2(seed)`

Please use this information for forensics purpose only ☺

```
USER_HMAC_KEY = '\xd1\x14\xa5R\x12e_t\xbdw.7\xe6J\xee\x9b'

APP_KEY = '\rc\x8c\t.\x8b\x82\xfcE(\x83\xf9_5[\x8e'

APP_IV = '\xd8\x9bC\x1f\xb6\x1d\xde\x1a\xfd\xa4\xb7\xf9\xf4\xb8\r\x05'

APP_ITER = 1066

USER_KEYLEN = 16

DB_KEYLEN = 16
```

Network protocols

NETWORK PROTOCOLS

Network traffic

- fully transported over HTTPS
- OpenSSL + nCrypt wrapper
- Proper certificate checking
  - Hardcoded CA list

```
root_certs = '#         Subject:
C=ZA, ST=Western Cape, L=Cape
Town, O=Thawte Consulting cc, (…)

-----BEGIN CERTIFICATE-----\n

MIIDEzCCAnygAwIBAgIBATA

(…)

L7tdEy8W9ViH0Pd\n

-----END CERTIFICATE-----\n\n'
```

NETWORK PROTOCOLS

Issues

OpenSSL … **0.9.8e** ?

- as of DropBox 1.4.17
- Hello **CVE-2011-4109**, **CVE-2012-2110**, and others

nCrypt … completely buggy and unsupported software?

http://bugs.debian.org/cgi-bin/bugreport.cgi?bug=614051

No patch since 2007

NETWORK PROTOCOLS

File synchronisation: RSYNC protocol

File storage: Amazon Cloud S3

Implementation details

- Blocks of 4 MB in size
- SHA-256 of each block
- Encryption is provided by SSL/TLS only

DROPBOX PROTOCOL

Servers of interest

Blockserver: manages 4MB blocks

Authserver: user authentication, software setup

Metaserver: handles information requests about files and directories

Metaexcserver / blockexcserver: handle exceptions

Statserver / notifyserver: statistics

```
set_server(ret, 'blockserver', secure=True, timeout=60, **non_exc_kwargs)
set_server(ret, 'metaserver', secure=True, timeout=90, **non_exc_kwargs)
set_server(ret, 'metaexcserver', secure=True, timeout=90, **exc_kwargs)
set_server(ret, 'blockexcserver', secure=True, timeout=90, **exc_kwargs)
set_server(ret, 'statserver', secure=True, timeout=90, **exc_kwargs)
set_server(ret, 'notifyserver', secure=False, timeout=90, **non_exc_kwargs)
```

DROPBOX PROTOCOL

HOST_ID

- Unique and forever user identifier
- 128-bit length
- Server-side generated on 1st installation
- Not affected by password change
- Stored in local configuration database

HOST_INT

- Unique identifier per device

NS_MAP

- User namespace identifier
- Killed "dropship" hack

  Before: **get_block(hash_for_block)**

  After: **get_block(hash_for_block ; ns_map + host_id)**

LAN sync protocol

LAN SYNC PROTOCOL

Local sync between two Dropbox clients

- Discovery: UDP/17500 broadcasts
- Data exchange: TCP/17500

Data exchange protocol

- Each Dropbox instance can act as a Client or a Server
- Client SSL/TLS authentication
  - Key pair in configuration database

LAN SYNC PROTOCOL

Attacking a client in server mode

- Requires a server-known key pair ☹

LAN SYNC PROTOCOL

Attacking the client mode

- Server certificate is not checked

LAN Sync protocol (redux)

- HELLO / HOWDY
- PING / PONG
- HAS / HASREPLY / HASFAIL (+ hash)
- GET / GETREPLY / GETFAIL (+ hash & file content)

LAN SYNC PROTOCOL

Demo !

QUESTIONS