How to securely isolate and execute Bruteforce Exploit Detector from Kali Linux

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This site is dedicated to sharing information about the practice, ideas, concepts and patterns regarding computer security.

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1. Introduction

The motivation behind this paper is to explore using the tool Bed that comes with Kali Linux Tools.

What is bed?

The Bruteforce Exploit Detector (BED) is a network protocol fuzzer. The program allows you to send random data to the target application in hopes that the effort will crash the application.

What is a Fuzzer/Fuzzing:

"Fuzzing or fuzz testing is an automated software testing technique that involves providing invalid, unexpected, or random data as inputs to a computer program. The program is then monitored for exceptions such as crashes, failing built-in code assertions, or potential memory leaks. Typically, fuzzers are used to test programs that take structured inputs. This structure is specified, e.g., in a file format or protocol and distinguishes valid from invalid input. An effective fuzzer generates semi-valid inputs that are "valid enough" in that they are not directly rejected by the parser, but do create unexpected behaviors deeper in the program and are "invalid enough" to expose corner cases that have not been properly dealt with.

For the purpose of security, input that crosses a trust boundary is often the most interesting. For example, it is more important to fuzz code that handles the upload of a file by any user than it is to fuzz the code that parses a configuration file that is accessible only to a privileged user." ***source***: Fuzzing

Usage for bed:

```
$ bed -s <plugin> -t <target> -p <port> -o <timeout> [ depends on the plugin ]

<plugin>   = FTP/SMTP/POP/HTTP/IRC/IMAP/PJL/LPD/FINGER/SOCKS4/SOCKS5
<target>   = Host to check (default: localhost)
<port>     = Port to connect to (default: standard port)
<timeout>  = seconds to wait after each test (default: 2 seconds)
use "bed -s <plugin>" to obtain the parameters you need for the plugin.

Only -s is a mandatory switch.
```

Example Usage

```
root@kali:~# bed -s HTTP -t 192.168.0.10

 BED 0.5 by mjm ( www.codito.de ) & eric ( www.snake-basket.de )

 + Buffer overflow testing:
        testing: 1  HEAD XAXAX HTTP/1.0
```

I am super excited to get started with this tool.

2. Requirements

2.1. Writing Conventions

If you see the following $ symbol on a command line to execute, what that means is that the command is executed as a regular user; meaning an account that does not have administrative privileges. Ignore the leading $ and execute the rest of the command.

```
$ command to execute as a regular user
```

If you see a command line lead with the # symbol, then that means that the command is executed as the root user. This implies you need to elevate to the root user before running the command, e.g. with: `sudo su - root`.

```
# command to execute as the root user
```

2.2. VirtualBox

Go to: https://www.virtualbox.org/wiki/Downloads and download VirtualBox.

The author is running on Ubuntu 18.04, so following to this URL: https://www.virtualbox.org/wiki/Linux_Downloads

For Ubuntu, double click on the .deb file, i.e. virtualbox-5.2_5.2.0-118431-Ubuntu-zesty_amd64.deb, and install VirtualBox on your local workstation.

2.2.1. Clean VirtualBox Networking

This section is here in case you already had virtualbox installed from before. The intent is to clean up the previous networking. If you do not need to do this, skip to Add VirtualBox Networking

Run these two commands from a Terminal:

```
$ VBoxManage list natnetworks
$ VBoxManage list dhcpservers
```

Output (example):

```
NetworkName:    192.168.139-NAT
IP:             192.168.139.1
Network:        192.168.139.0/24
IPv6 Enabled:   No
IPv6 Prefix:    fd17:625c:f037:2::/64
DHCP Enabled:   Yes
Enabled:        Yes
loopback mappings (ipv4)
        127.0.0.1=2


NetworkName:    192.168.139-NAT
Dhcpd IP:       192.168.139.3
LowerIPAddress: 192.168.139.101
UpperIPAddress: 192.168.139.254
NetworkMask:    255.255.255.0
Enabled:        Yes
Global Configuration:
    minLeaseTime:     default
    defaultLeaseTime: default
    maxLeaseTime:     default
    Forced options:   None
    Suppressed opts.: None
        1/legacy: 255.255.255.0
Groups:               None
Individual Configs:   None

NetworkName:    HostInterfaceNetworking-vboxnet0
Dhcpd IP:       172.20.0.3
LowerIPAddress: 172.20.0.101
UpperIPAddress: 172.20.0.254
NetworkMask:    255.255.255.0
Enabled:        Yes
Global Configuration:
    minLeaseTime:     default
    defaultLeaseTime: default
    maxLeaseTime:     default
    Forced options:   None
    Suppressed opts.: None
        1/legacy: 255.255.255.0
Groups:               None
Individual Configs:   None
```

Now, delete ALL of the pre-installed VirtualBox networks (one at a time following the syntax below):

```
VBoxManage natnetwork remove --netname <NetworkName_from_above>
VBoxManage natnetwork remove --netname 192.168.139-NAT
```

Repeat as many times as necessary to delete all of them.

Now, delete ALL of the pre-installed DHCP services:

```
VBoxManage dhcpserver remove --netname <DHCP_Server_NetworkName_from_above>
VBoxManage dhcpserver remove --netname 192.168.139-NAT
```

Repeat as many times as necessary to delete all of them.

2.2.2. Add VirtualBox Networking

Now, add the new VirtualBox networks so the Kali Linux guides work.

```
VBoxManage natnetwork add \
    --netname 192.168.139-NAT \
    --network "192.168.139.0/24" \
    --enable --dhcp on

VBoxManage dhcpserver add \
    --netname 192.168.139-NAT \
    --ip 192.168.139.3 \
    --lowerip 192.168.139.101 \
    --upperip 192.168.139.254 \
    --netmask 255.255.255.0 \
    --enable

VBoxManage hostonlyif create

VBoxManage hostonlyif ipconfig vboxnet0 \
    --ip 172.20.0.1 \
    --netmask 255.255.255.0

VBoxManage dhcpserver add \
    --ifname vboxnet0 \
    --ip 172.20.0.3 \
    --lowerip 172.20.0.101 \
    --upperip 172.20.0.254 \
    --netmask 255.255.255.0

VBoxManage dhcpserver modify \
    --ifname vboxnet0 \
    --enable
```

VirtualBox install complete.

2.3. Vagrant

Go to: https://www.vagrantup.com/downloads.html, follow the appropriate link to your OS and 32 or 64 bit version representing your local workstation. Download.

For Ubuntu, double click on the .deb file, i.e. vagrant_2.0.1_x86_64.deb, and install Vagrant on your local system.

2.4. Kali Linux and Damn Vulnerable Web Application (DVWA)

The author highly recommends to create a directory structure that is easy to navigate and find your code. As an example, you could use something similar to:

```
${HOME}/Source_Code/Education/vagrant-machines/kali-linux-vm/
```

Go ahead and make this structure with the following command (inside a Terminal):

```
$ mkdir -p ${HOME}/Source_Code/Education/vagrant-machines/kali-linux-vm/
```

From a Terminal, change directory to:

```
$ cd ${HOME}/Source_Code/Education/vagrant-machines/kali-linux-vm/
```

2.4.1. Vagrantfile

Inside of the kali-linux-vm directory, populate a new file with the exact name, “Vagrantfile”. Case matters, uppercase the “V”. This file will contain both virtual machines for Kali Linux as well as setting up the DVWA virtual machine.

Aggregating both virtual machines into one file has saved the author a lot of time. The coolness here is setting up the variables at the top of the Vagrantfile mimicing shell scripting inside of a virtual machine (passed in with provision: shell). I tested using: `apt-get update && apt-get upgrade -y`, but opted to take it out since it took over 45 minutes on my slower (old) hardware. See comment about downloading this file immediately preceding the code block.

```
# -*- mode: ruby -*-
# vi: set ft=ruby :

$os_update = <<SCRIPT
apt-get update
SCRIPT

VAGRANTFILE_API_VERSION = "2"


Vagrant.configure(VAGRANTFILE_API_VERSION) do |config|
    config.vm.define "kali-linux-vagrant" do |conf|
        conf.vm.box = "kalilinux/rolling"

        # For Linux systems with the Wireless network, uncomment the line:
        conf.vm.network "public_network", bridge: "wlo1", auto_config: true

        # For macbook/OSx systems, uncomment the line and comment out the Linux Wireless network:
        #conf.vm.network "public_network", bridge: "en0: Wi-Fi (AirPort)", auto_config: true

        conf.vm.hostname = "kali-linux-vagrant"
        conf.vm.provider "virtualbox" do |vb|
            vb.gui = true
            vb.memory = "4096"
            vb.cpus = "2"
            vb.customize ["modifyvm", :id, "--vram", "32"]
            vb.customize ["modifyvm", :id, "--accelerate3d", "off"]
            vb.customize ["modifyvm", :id, "--ostype", "Debian_64"]
            vb.customize ["modifyvm", :id, "--boot1", "dvd"]
            vb.customize ["modifyvm", :id, "--boot2", "disk"]
            vb.customize ["modifyvm", :id, "--audio", "none"]
            vb.customize ["modifyvm", :id, "--clipboard", "hosttoguest"]
            vb.customize ["modifyvm", :id, "--draganddrop", "hosttoguest"]
            vb.customize ["modifyvm", :id, "--paravirtprovider", "kvm"]
        end
        conf.vm.provision "shell", inline: $os_update
    end

    config.vm.define "dvwa-vagrant" do |conf|

        conf.vm.box = "ubuntu/xenial64"

        conf.vm.hostname = "dvwa-vagrant"

        # For Linux systems with the Wireless network, uncomment the line:
        conf.vm.network "public_network", bridge: "wlo1", auto_config: true

        # For macbook/OSx systems, uncomment the line and comment out the Linux Wireless network:
        #conf.vm.network "public_network", bridge: "en0: Wi-Fi (AirPort)", auto_config: true

        config.vm.network "forwarded_port", guest: 80, host: 8080, auto_correct: true
        config.vm.network "forwarded_port", guest: 3306, host: 3306, auto_correct: true

        conf.vm.provider "virtualbox" do |vb|
            vb.memory = "1024"
            vb.cpus = "2"
            vb.gui = false
            vb.customize ["modifyvm", :id, "--vram", "32"]
            vb.customize ["modifyvm", :id, "--accelerate3d", "off"]
            vb.customize ["modifyvm", :id, "--ostype", "Ubuntu_64"]
            vb.customize ["modifyvm", :id, "--boot1", "dvd"]
            vb.customize ["modifyvm", :id, "--boot2", "disk"]
            vb.customize ["modifyvm", :id, "--audio", "none"]
            vb.customize ["modifyvm", :id, "--clipboard", "hosttoguest"]
            vb.customize ["modifyvm", :id, "--draganddrop", "hosttoguest"]
            vb.customize ["modifyvm", :id, "--paravirtprovider", "kvm"]
        end
        conf.vm.provision "shell", inline: $os_update
        conf.vm.provision :shell, path: "bootstrap.sh"
    end
end
```

Save and write this file.

You can also download from:

```
$ curl -o Vagrantfile  http://securityhardening.com/files/Vagrantfile_20200928.txt
```

2.4.2. bootstrap.sh

Inside of the kali-linux-vm directory, populate a new file with the exact name, `bootstrap.sh`. Case matters, all lowercase. See comment about downloading this file immediately preceding the code block. `bootstrap.sh` (include the shebang in your file: the first line with `#!/usr/bin/env bash`):

```
#!/usr/bin/env bash
PHP_FPM_PATH_INI='/etc/php/7.0/fpm/php.ini'
PHP_FPM_POOL_CONF='/etc/php/7.0/fpm/pool.d/www.conf'
MYSQL_ROOT_PW='Assword12345'
MYSQL_dvwa_user='dvwa'
MYSQL_dvwa_password='sunshine'
DVWA_admin_password='admin'
recaptcha_public_key='u8392ihj32kl8hujalkshuil32'
recaptcha_private_key='89ry8932873832lih32ilj32'


install_base() {
    add-apt-repository -y ppa:nginx/stable
    sudo apt-get update
    sudo apt-get dist-upgrade -y
    sudo apt-get install -y \
        nginx \
        mariadb-server \
        mariadb-client \
        php \
        php-common \
        php-cgi \
        php-fpm \
        php-gd \
        php-cli \
        php-pear \
        php-mcrypt \
        php-mysql \
        php-gd \
        git \
        vim
}

config_mysql(){
    mysqladmin -u root password "${MYSQL_ROOT_PW}"
## Config the mysql config file for root so it doesn't prompt for password.
## Also sets pw in plain text for easy access.
## Don't forget to change the password here!!

cat <<EOF > /root/.my.cnf
[client]
user="root"
password="${MYSQL_ROOT_PW}"
EOF
    mysql -BNe "drop database if exists dvwa;"
    mysql -BNe "CREATE DATABASE dvwa;"
    mysql -BNe "GRANT ALL ON *.* TO '"${MYSQL_dvwa_user}"'@'localhost' IDENTIFIED BY '"${MYSQL_dvwa_password}"';"

    systemctl enable mysql
    systemctl restart mysql
    sleep 2
}


config_php(){
    ## Config PHP FPM INI to disable some security settings:

    sed -i 's/^;cgi.fix_pathinfo.*$/cgi.fix_pathinfo = 0/g' ${PHP_FPM_PATH_INI}
    sed -i 's/allow_url_include = Off/allow_url_include = On/g' ${PHP_FPM_PATH_INI}
```

```
    sed -i 's/allow_url_fopen = Off/allow_url_fopen = On/g' ${PHP_FPM_PATH_INI}
    sed -i 's/safe_mode = On/safe_mode = Off/g' ${PHP_FPM_PATH_INI}
    echo "magic_quotes_gpc = Off" >> ${PHP_FPM_PATH_INI}
    sed -i 's/display_errors = Off/display_errors = On/g' ${PHP_FPM_PATH_INI}

    ## explicitly set pool options
    ## (these are defaults in ubuntu 16.04 so i'm commenting them out.
    ## If they are not defaults for you try uncommenting these)
    #sed -i 's/^;security.limit_extensions.*$/security.limit_extensions = \
    #.php .php3 .php4 .php5 .php7/g' /etc/php/7.0/fpm/pool.d/www.conf
    #sed -i 's/^listen.owner.*$/listen.owner = www-data/g' /etc/php/7.0/fpm/pool.d/www.conf
    #sed -i 's/^listen.group.*$/listen.group = www-data/g' /etc/php/7.0/fpm/pool.d/www.conf
    #sed -i 's/^;listen.mode.*$/listen.mode = 0660/g' /etc/php/7.0/fpm/pool.d/www.conf


    systemctl restart php7.0-fpm
}


config_nginx(){

cat << 'EOF' > /etc/nginx/sites-enabled/default
server
{
    listen  80;
    root /var/www/html;
    index index.php index.html index.htm;
    #server_name localhost
    location "/"
    {
        index index.php index.html index.htm;
        #try_files $uri $uri/ =404;
    }

    location ~ \.php$
    {
        include /etc/nginx/fastcgi_params;
        fastcgi_pass unix:/var/run/php/php7.0-fpm.sock;
        fastcgi_index index.php;
        fastcgi_param SCRIPT_FILENAME $request_filename;
    }
}
EOF

    systemctl restart nginx
}


install_dvwa(){

    if [[ ! -d "/var/www/html" ]];
    then
          mkdir -p /var/www;
          ln -s /usr/share/nginx/html /var/www/html;
          chown -R www-data. /var/www/html;
    fi

    cd /var/www/html
    rm -rf /var/www/html/.[!.]*
    rm -rf /var/www/html/*
    git clone https://github.com/ethicalhack3r/DVWA.git ./
    chown -R www-data. ./
    cp config/config.inc.php.dist config/config.inc.php

    ### chmod uploads and log file to be writable by nobody
    chmod 777 ./hackable/uploads/
    chmod 777 ./external/phpids/0.6/lib/IDS/tmp/phpids_log.txt

    ## change the values in the config to match our setup (these are what you need to update!
    sed -i '/db_user/ s/root/'${MYSQL_dvwa_user}'/' /var/www/html/config/config.inc.php
    sed -i '/db_password/ s/p@ssw0rd/'${MYSQL_dvwa_password}'/' /var/www/html/config/config.inc.php
    sed -i "/recaptcha_public_key/ s/''/'"${recaptcha_public_key}"'/" /var/www/html/config/config.inc.php
    sed -i "/recaptcha_private_key/ s/''/'"${recaptcha_private_key}"'/" /var/www/html/config/config.inc.php

}
```

```
update_mysql_user_pws(){
## The mysql passwords are set via /usr/share/nginx/html/dvwa/includes/DBMS/MySQL.php.
#  If you edit this every time they are reset it will reset to those.
#  Otherwise you can do a sql update statement to update them all (they are just md5's of the string.
#  The issue is the users table doesn't get created until you click that button T_T to init.

#mysql -BNe "UPDATE dvwa.users SET password = md5('YOUR_MYSQL_PW_HERE') WHERE user = 'admin';"
#mysql -BNe "UPDATE dvwa.users SET password = md5('YOUR_MYSQL_PW_HERE') WHERE user = 'gordonb';"
#mysql -BNe "UPDATE dvwa.users SET password = md5('YOUR_MYSQL_PW_HERE') WHERE user = '1337';"
#mysql -BNe "UPDATE dvwa.users SET password = md5('YOUR_MYSQL_PW_HERE') WHERE user = 'pablo';"
#mysql -BNe "UPDATE dvwa.users SET password = md5('YOUR_MYSQL_PW_HERE') WHERE user = 'smithy';"

sed -i '/admin/ s/password/'${DVWA_admin_password}'/g'  /var/www/html/dvwa/includes/DBMS/MySQL.php
sed -i '/gordonb/ s/abc123/'${DVWA_admin_password}'/g'  /var/www/html/dvwa/includes/DBMS/MySQL.php
sed -i '/1337/ s/charley/'${DVWA_admin_password}'/g'  /var/www/html/dvwa/includes/DBMS/MySQL.php
sed -i '/pablo/ s/letmein/'${DVWA_admin_password}'/g'  /var/www/html/dvwa/includes/DBMS/MySQL.php
sed -i '/smithy/ s/password/'${DVWA_admin_password}'/g'  /var/www/html/dvwa/includes/DBMS/MySQL.php
}


install_base
config_mysql
install_dvwa
update_mysql_user_pws
config_php
config_nginx
```

Save and write this file.

If you have issues with copying and pasting the above file because code blocks in PDFs always copy correctly [NOT!], you could use curl, i.e. Make sure the bootstrap.sh file ends up in the same directory as the Vagrantfile.

```
$ curl -o bootstrap.sh  http://securityhardening.com/files/bootstrap_sh_20200928.txt
```

From a Terminal, change directory to:

```
$ cd ${HOME}/Source_Code/Education/vagrant-machines/kali-linux-vm/
```

Then run (inside the directory kali-linux-vm):

```
$ vagrant up
```

This will download the appropriate images and start the virtual machines. Once running, through the VirtuaBox GUI, login as root. Password is “toor”, root backwards. Edit the following file: `/etc/ssh/sshd_config`

And change the line: `#PermitRootLogin prothibit-password` To: `PermitRootLogin yes` Meaning strip the comment out on the beginning of the line and alter `prohibit-password` to `yes`.

Then restart the ssh daemon:

```
# kill -HUP $(pgrep sshd)
```

Notice, you are on a Bridged adapter, this will open the instance to allow root to ssh in with the most unsecure password in the world. Only make this change (allowing root to login via SSH) if you require root SSH access. You can change the root user’s password, which is highly recommended.

For the DVWA instance, I would first run 'vagrant status' to capture the name that vagrant is using for the running instance.

```
# vagrant status
```

Choose

```
Current machine states:
kali-linux-vagrant running (virtualbox)
dvwa-vagrant running (virtualbox)
```

This environment represents multiple VMs. The VMs are all listed above with their current state. For more information about a specific VM, run `vagrant status NAME`.

From there, log into the DVWA instance with:

```
$ vagrant ssh dvwa-vagrant
```

And then get the current IP address.

```
$ ip a
```

Choose the second network adapter, it should look like:

```
ubuntu@dvwa:~$ ip a
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
        valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
        valid_lft forever preferred_lft forever
2: enp0s3: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP group default qlen 1000
    link/ether 02:53:17:3c:de:80 brd ff:ff:ff:ff:ff:ff
    inet 10.0.2.15/24 brd 10.0.2.255 scope global enp0s3
        valid_lft forever preferred_lft forever
    inet6 fe80::53:17ff:fe3c:de80/64 scope link
        valid_lft forever preferred_lft forever
3: enp0s8: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc pfifo_fast state UP group default qlen 1000
    link/ether 08:00:27:f0:77:2d brd ff:ff:ff:ff:ff:ff
    inet 172.20.156.76/24 brd 172.20.156.255 scope global enp0s8
        valid_lft forever preferred_lft forever
    inet6 fe80::a00:27ff:fef0:772d/64 scope link
        valid_lft forever preferred_lft forever
```

The test network used for this paper uses 172.20.156.0/24 as the network range [shown here in section 3]. Therefore, the adapter, enp0s8 is what he is looking for. The IP to use as a target is 172.20.156.76. Write down your value.

3. Bed

On your Host system, running VirtualBox and Vagrant, open a teminal and run:

```
$ vagrant status
```

Then SSH into the Kali Linux namespace

```
$ vagrant ssh kali-linux-vagrant
```

Elevate to the root user (inside the Virtual Machine for Kali Linux)

```
$ sudo su -
```

Install bed (inside the Virtual Machine for Kali Linux)

```
# apt-get install -y bed
```

In case my IP address Changed for DVWA, I am going to run this command from my Host to verify the IP

```
$ vagrant ssh dvwa-vagrant -c "ip a"
```

From inside of Kali Linux, let us launch our attack with BED

```
# ( time /usr/bin/bed -s HTTP -t 172.20.156.143 & ) 1> /tmp/bed.out 2>&1
```

`-s` is our protocol `-t` is our target

Output from the bed tool

```
 BED 0.5 by mjm ( www.codito.de ) & eric ( www.snake-basket.de )

 + Buffer overflow testing:
        testing: 1  HEAD XAXAX HTTP/1.0 ...........
        testing: 2  HEAD / XAXAX    ...........
        testing: 3  GET XAXAX HTTP/1.0  ...........
        testing: 4  GET / XAXAX ...........
        testing: 5  POST XAXAX HTTP/1.0 ...........
        testing: 6  POST / XAXAX    ...........
        testing: 7  GET /XAXAX  ...........
        testing: 8  POST /XAXAX ...........
 + Formatstring testing:
        testing: 1  HEAD XAXAX HTTP/1.0 .......
        testing: 2  HEAD / XAXAX    .......
        testing: 3  GET XAXAX HTTP/1.0  .......
        testing: 4  GET / XAXAX .......
        testing: 5  POST XAXAX HTTP/1.0 .......
        testing: 6  POST / XAXAX    .......
        testing: 7  GET /XAXAX  .......
        testing: 8  POST /XAXAX .......
* Normal tests
 + Buffer overflow testing:
        testing: 1  User-Agent: XAXAX   ...........
        testing: 2  Host: XAXAX ...........
        testing: 3  Accept: XAXAX   ...........
```

```
       testing: 4  Accept-Encoding: XAXAX  ..........
       testing: 5  Accept-Language: XAXAX  ..........
       testing: 6  Accept-Charset: XAXAX   ..........
       testing: 7  Connection: XAXAX   ..........
       testing: 8  Referer: XAXAX  ..........
       testing: 9  Authorization: XAXAX    ..........
       testing: 10 From: XAXAX ..........
       testing: 11 Charge-To: XAXAX    ..........
       testing: 12 Authorization: XAXAX    ..........
       testing: 13 Authorization: XAXAX : foo  ..........
       testing: 14 Authorization: foo : XAXAX  ..........
       testing: 15 If-Modified-Since: XAXAX    ..........
       testing: 16 ChargeTo: XAXAX ..........
       testing: 17 Pragma: XAXAX   ..........
+ Formatstring testing:
       testing: 1  User-Agent: XAXAX   .......
       testing: 2  Host: XAXAX .......
       testing: 3  Accept: XAXAX   .......
       testing: 4  Accept-Encoding: XAXAX  .......
       testing: 5  Accept-Language: XAXAX  .......
       testing: 6  Accept-Charset: XAXAX   .......
       testing: 7  Connection: XAXAX   .......
       testing: 8  Referer: XAXAX  .......
       testing: 9  Authorization: XAXAX    .......
       testing: 10 From: XAXAX .......
       testing: 11 Charge-To: XAXAX    .......
       testing: 12 Authorization: XAXAX    .......
       testing: 13 Authorization: XAXAX : foo  .......
       testing: 14 Authorization: foo : XAXAX  .......
       testing: 15 If-Modified-Since: XAXAX    .......
       testing: 16 ChargeTo: XAXAX .......
       testing: 17 Pragma: XAXAX   .......
+ Unicode testing:
       testing: 1  User-Agent: XAXAX   .......
       testing: 2  Host: XAXAX .......
       testing: 3  Accept: XAXAX   .......
       testing: 4  Accept-Encoding: XAXAX  .......
       testing: 5  Accept-Language: XAXAX  .......
       testing: 6  Accept-Charset: XAXAX   .......
       testing: 7  Connection: XAXAX   .......
       testing: 8  Referer: XAXAX  .......
       testing: 9  Authorization: XAXAX    .......
       testing: 10 From: XAXAX .......
       testing: 11 Charge-To: XAXAX    .......
       testing: 12 Authorization: XAXAX    .......
       testing: 13 Authorization: XAXAX : foo  .......
       testing: 14 Authorization: foo : XAXAX  .......
       testing: 15 If-Modified-Since: XAXAX    .......
       testing: 16 ChargeTo: XAXAX .......
       testing: 17 Pragma: XAXAX   .......
+ random number testing:
       testing: 1  User-Agent: XAXAX   ............
       testing: 2  Host: XAXAX ............
       testing: 3  Accept: XAXAX   ............
       testing: 4  Accept-Encoding: XAXAX  ............
       testing: 5  Accept-Language: XAXAX  ............
       testing: 6  Accept-Charset: XAXAX   ............
       testing: 7  Connection: XAXAX   ............
       testing: 8  Referer: XAXAX  ............
       testing: 9  Authorization: XAXAX    ............
       testing: 10 From: XAXAX ............
       testing: 11 Charge-To: XAXAX    ............
       testing: 12 Authorization: XAXAX    ............
       testing: 13 Authorization: XAXAX : foo  ............
       testing: 14 Authorization: foo : XAXAX  ............
       testing: 15 If-Modified-Since: XAXAX    ............
       testing: 16 ChargeTo: XAXAX ............
       testing: 17 Pragma: XAXAX   ............
+ testing misc strings 1:
       testing: 1  User-Agent: XAXAX   ..............
       testing: 2  Host: XAXAX ..............
       testing: 3  Accept: XAXAX   ..............
       testing: 4  Accept-Encoding: XAXAX  ..............
       testing: 5  Accept-Language: XAXAX  ..............
       testing: 6  Accept-Charset: XAXAX   ..............
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       testing: 7  Connection: XAXAX   ..............
       testing: 8  Referer: XAXAX  ..............
       testing: 9  Authorization: XAXAX    ..............
       testing: 10 From: XAXAX ..............
       testing: 11 Charge-To: XAXAX    ..............
       testing: 12 Authorization: XAXAX    ..............
       testing: 13 Authorization: XAXAX : foo  ..............
       testing: 14 Authorization: foo : XAXAX  ..............
       testing: 15 If-Modified-Since: XAXAX    ..............
       testing: 16 ChargeTo: XAXAX ..............
       testing: 17 Pragma: XAXAX   ..............
+ testing misc strings 2:
       testing: 1  User-Agent: XAXAX   ..............
       testing: 2  Host: XAXAX ..............
       testing: 3  Accept: XAXAX   ..............
       testing: 4  Accept-Encoding: XAXAX  ..............
       testing: 5  Accept-Language: XAXAX  ..............
       testing: 6  Accept-Charset: XAXAX   ..............
       testing: 7  Connection: XAXAX   ..............
       testing: 8  Referer: XAXAX  ..............
       testing: 9  Authorization: XAXAX    ..............
       testing: 10 From: XAXAX ..............
       testing: 11 Charge-To: XAXAX    ..............
       testing: 12 Authorization: XAXAX    ..............
       testing: 13 Authorization: XAXAX : foo  ..............
       testing: 14 Authorization: foo : XAXAX  ..............
       testing: 15 If-Modified-Since: XAXAX    ..............
       testing: 16 ChargeTo: XAXAX ..............
       testing: 17 Pragma: XAXAX   ..............
+ testing misc strings 3:
       testing: 1  User-Agent: XAXAX   ..............
       testing: 2  Host: XAXAX ..............
       testing: 3  Accept: XAXAX   ..............
       testing: 4  Accept-Encoding: XAXAX  ..............
       testing: 5  Accept-Language: XAXAX  ..............
       testing: 6  Accept-Charset: XAXAX   ..............
       testing: 7  Connection: XAXAX   ..............
       testing: 8  Referer: XAXAX  ..............
       testing: 9  Authorization: XAXAX    ..............
       testing: 10 From: XAXAX ..............
       testing: 11 Charge-To: XAXAX    ..............
       testing: 12 Authorization: XAXAX    ..............
       testing: 13 Authorization: XAXAX : foo  ..............
       testing: 14 Authorization: foo : XAXAX  ..............
       testing: 15 If-Modified-Since: XAXAX    ..............
       testing: 16 ChargeTo: XAXAX ..............
       testing: 17 Pragma: XAXAX   ..............
+ testing misc strings 4:
       testing: 1  User-Agent: XAXAX   ..............
       testing: 2  Host: XAXAX ..............
       testing: 3  Accept: XAXAX   ..............
       testing: 4  Accept-Encoding: XAXAX  ..............
       testing: 5  Accept-Language: XAXAX  ..............
       testing: 6  Accept-Charset: XAXAX   ..............
       testing: 7  Connection: XAXAX   ..............
       testing: 8  Referer: XAXAX  ..............
       testing: 9  Authorization: XAXAX    ..............
       testing: 10 From: XAXAX ..............
       testing: 11 Charge-To: XAXAX    ..............
       testing: 12 Authorization: XAXAX    ..............
       testing: 13 Authorization: XAXAX : foo  ..............
       testing: 14 Authorization: foo : XAXAX  ..............
       testing: 15 If-Modified-Since: XAXAX    ..............
       testing: 16 ChargeTo: XAXAX ..............
       testing: 17 Pragma: XAXAX   ..............
+ testing misc strings 5:
       testing: 1  User-Agent: XAXAX   ..............
       testing: 2  Host: XAXAX ..............
       testing: 3  Accept: XAXAX   ..............
       testing: 4  Accept-Encoding: XAXAX  ..............
       testing: 5  Accept-Language: XAXAX  ..............
       testing: 6  Accept-Charset: XAXAX   ..............
       testing: 7  Connection: XAXAX   ..............
       testing: 8  Referer: XAXAX  ..............
       testing: 9  Authorization: XAXAX    ..............
```

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       testing: 10 From: XAXAX ..............
       testing: 11 Charge-To: XAXAX    ..............
       testing: 12 Authorization: XAXAX    ..............
       testing: 13 Authorization: XAXAX : foo  ..............
       testing: 14 Authorization: foo : XAXAX  ..............
       testing: 15 If-Modified-Since: XAXAX    ..............
       testing: 16 ChargeTo: XAXAX ..............
       testing: 17 Pragma: XAXAX   ..............
+ testing misc strings 6:
       testing: 1  User-Agent: XAXAX   ..............
       testing: 2  Host: XAXAX ..............
       testing: 3  Accept: XAXAX   ..............
       testing: 4  Accept-Encoding: XAXAX  ..............
       testing: 5  Accept-Language: XAXAX  ..............
       testing: 6  Accept-Charset: XAXAX   ..............
       testing: 7  Connection: XAXAX   ..............
       testing: 8  Referer: XAXAX  ..............
       testing: 9  Authorization: XAXAX    ..............
       testing: 10 From: XAXAX ..............
       testing: 11 Charge-To: XAXAX    ..............
       testing: 12 Authorization: XAXAX    ..............
       testing: 13 Authorization: XAXAX : foo  ..............
       testing: 14 Authorization: foo : XAXAX  ..............
       testing: 15 If-Modified-Since: XAXAX    ..............
       testing: 16 ChargeTo: XAXAX ..............
       testing: 17 Pragma: XAXAX   ..............
+ testing misc strings 7:
       testing: 1  User-Agent: XAXAX   ..............
       testing: 2  Host: XAXAX ..............
       testing: 3  Accept: XAXAX   ..............
       testing: 4  Accept-Encoding: XAXAX  ..............
       testing: 5  Accept-Language: XAXAX  ..............
       testing: 6  Accept-Charset: XAXAX   ..............
       testing: 7  Connection: XAXAX   ..............
       testing: 8  Referer: XAXAX  ..............
       testing: 9  Authorization: XAXAX    ..............
       testing: 10 From: XAXAX ..............
       testing: 11 Charge-To: XAXAX    ..............
       testing: 12 Authorization: XAXAX    ..............
       testing: 13 Authorization: XAXAX : foo  ..............
       testing: 14 Authorization: foo : XAXAX  ..............
       testing: 15 If-Modified-Since: XAXAX    ..............
       testing: 16 ChargeTo: XAXAX ..............
       testing: 17 Pragma: XAXAX   ..............
+ testing misc strings 8:
       testing: 1  User-Agent: XAXAX   ..............
       testing: 2  Host: XAXAX ..............
       testing: 3  Accept: XAXAX   ..............
       testing: 4  Accept-Encoding: XAXAX  ..............
       testing: 5  Accept-Language: XAXAX  ..............
       testing: 6  Accept-Charset: XAXAX   ..............
       testing: 7  Connection: XAXAX   ..............
       testing: 8  Referer: XAXAX  ..............
       testing: 9  Authorization: XAXAX    ..............
       testing: 10 From: XAXAX ..............
       testing: 11 Charge-To: XAXAX    ..............
       testing: 12 Authorization: XAXAX    ..............
       testing: 13 Authorization: XAXAX : foo  ..............
       testing: 14 Authorization: foo : XAXAX  ..............
       testing: 15 If-Modified-Since: XAXAX    ..............
       testing: 16 ChargeTo: XAXAX ..............
       testing: 17 Pragma: XAXAX   ..............
+ testing misc strings 9:
       testing: 1  User-Agent: XAXAX   ..............
       testing: 2  Host: XAXAX ..............
       testing: 3  Accept: XAXAX   ..............
       testing: 4  Accept-Encoding: XAXAX  ..............
       testing: 5  Accept-Language: XAXAX  ..............
       testing: 6  Accept-Charset: XAXAX   ..............
       testing: 7  Connection: XAXAX   ..............
       testing: 8  Referer: XAXAX  ..............
       testing: 9  Authorization: XAXAX    ..............
       testing: 10 From: XAXAX ..............
       testing: 11 Charge-To: XAXAX    ..............
       testing: 12 Authorization: XAXAX    ..............
```

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       testing: 13 Authorization: XAXAX : foo  ..............
       testing: 14 Authorization: foo : XAXAX  ..............
       testing: 15 If-Modified-Since: XAXAX    ..............
       testing: 16 ChargeTo: XAXAX ..............
       testing: 17 Pragma: XAXAX   ..............
+ testing misc strings 10:
       testing: 1  User-Agent: XAXAX   ..............
       testing: 2  Host: XAXAX ..............
       testing: 3  Accept: XAXAX   ..............
       testing: 4  Accept-Encoding: XAXAX  ..............
       testing: 5  Accept-Language: XAXAX  ..............
       testing: 6  Accept-Charset: XAXAX   ..............
       testing: 7  Connection: XAXAX   ..............
       testing: 8  Referer: XAXAX  ..............
       testing: 9  Authorization: XAXAX    ..............
       testing: 10 From: XAXAX ..............
       testing: 11 Charge-To: XAXAX    ..............
       testing: 12 Authorization: XAXAX    ..............
       testing: 13 Authorization: XAXAX : foo  ..............
       testing: 14 Authorization: foo : XAXAX  ..............
       testing: 15 If-Modified-Since: XAXAX    ..............
       testing: 16 ChargeTo: XAXAX ..............
       testing: 17 Pragma: XAXAX   ..............
+ testing misc strings 11:
       testing: 1  User-Agent: XAXAX   ..............
       testing: 2  Host: XAXAX ..............
       testing: 3  Accept: XAXAX   ..............
       testing: 4  Accept-Encoding: XAXAX  ..............
       testing: 5  Accept-Language: XAXAX  ..............
       testing: 6  Accept-Charset: XAXAX   ..............
       testing: 7  Connection: XAXAX   ..............
       testing: 8  Referer: XAXAX  ..............
       testing: 9  Authorization: XAXAX    ..............
       testing: 10 From: XAXAX ..............
       testing: 11 Charge-To: XAXAX    ..............
       testing: 12 Authorization: XAXAX    ..............
       testing: 13 Authorization: XAXAX : foo  ..............
       testing: 14 Authorization: foo : XAXAX  ..............
       testing: 15 If-Modified-Since: XAXAX    ..............
       testing: 16 ChargeTo: XAXAX ..............
       testing: 17 Pragma: XAXAX   ..............
+ testing misc strings 12:
       testing: 1  User-Agent: XAXAX   ..............
       testing: 2  Host: XAXAX ..............
       testing: 3  Accept: XAXAX   ..............
       testing: 4  Accept-Encoding: XAXAX  ..............
       testing: 5  Accept-Language: XAXAX  ..............
       testing: 6  Accept-Charset: XAXAX   ..............
       testing: 7  Connection: XAXAX   ..............
       testing: 8  Referer: XAXAX  ..............
       testing: 9  Authorization: XAXAX    ..............
       testing: 10 From: XAXAX ..............
       testing: 11 Charge-To: XAXAX    ..............
       testing: 12 Authorization: XAXAX    ..............
       testing: 13 Authorization: XAXAX : foo  ..............
       testing: 14 Authorization: foo : XAXAX  ..............
       testing: 15 If-Modified-Since: XAXAX    ..............
       testing: 16 ChargeTo: XAXAX ..............
       testing: 17 Pragma: XAXAX   ..............
+ testing misc strings 13:
       testing: 1  User-Agent: XAXAX   ..............
       testing: 2  Host: XAXAX ..............
       testing: 3  Accept: XAXAX   ..............
       testing: 4  Accept-Encoding: XAXAX  ..............
       testing: 5  Accept-Language: XAXAX  ..............
       testing: 6  Accept-Charset: XAXAX   ..............
       testing: 7  Connection: XAXAX   ..............
       testing: 8  Referer: XAXAX  ..............
       testing: 9  Authorization: XAXAX    ..............
       testing: 10 From: XAXAX ..............
       testing: 11 Charge-To: XAXAX    ..............
       testing: 12 Authorization: XAXAX    ..............
       testing: 13 Authorization: XAXAX : foo  ..............
       testing: 14 Authorization: foo : XAXAX  ..............
       testing: 15 If-Modified-Since: XAXAX    ..............
```

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       testing: 16 ChargeTo: XAXAX ..............
       testing: 17 Pragma: XAXAX   ..............
+ testing misc strings 14:
       testing: 1  User-Agent: XAXAX   ..............
       testing: 2  Host: XAXAX ..............
       testing: 3  Accept: XAXAX   ..............
       testing: 4  Accept-Encoding: XAXAX  ..............
       testing: 5  Accept-Language: XAXAX  ..............
       testing: 6  Accept-Charset: XAXAX   ..............
       testing: 7  Connection: XAXAX   ..............
       testing: 8  Referer: XAXAX  ..............
       testing: 9  Authorization: XAXAX    ..............
       testing: 10 From: XAXAX ..............
       testing: 11 Charge-To: XAXAX    ..............
       testing: 12 Authorization: XAXAX    ..............
       testing: 13 Authorization: XAXAX : foo  ..............
       testing: 14 Authorization: foo : XAXAX  ..............
       testing: 15 If-Modified-Since: XAXAX    ..............
       testing: 16 ChargeTo: XAXAX ..............
       testing: 17 Pragma: XAXAX   ..............
+ testing misc strings 15:
       testing: 1  User-Agent: XAXAX   ..............
       testing: 2  Host: XAXAX ..............
       testing: 3  Accept: XAXAX   ..............
       testing: 4  Accept-Encoding: XAXAX  ..............
       testing: 5  Accept-Language: XAXAX  ..............
       testing: 6  Accept-Charset: XAXAX   ..............
       testing: 7  Connection: XAXAX   ..............
       testing: 8  Referer: XAXAX  ..............
       testing: 9  Authorization: XAXAX    ..............
       testing: 10 From: XAXAX ..............
       testing: 11 Charge-To: XAXAX    ..............
       testing: 12 Authorization: XAXAX    ..............
       testing: 13 Authorization: XAXAX : foo  ..............
       testing: 14 Authorization: foo : XAXAX  ..............
       testing: 15 If-Modified-Since: XAXAX    ..............
       testing: 16 ChargeTo: XAXAX ..............
       testing: 17 Pragma: XAXAX   ..............
+ testing misc strings 16:
       testing: 1  User-Agent: XAXAX   ..............
       testing: 2  Host: XAXAX ..............
       testing: 3  Accept: XAXAX   ..............
       testing: 4  Accept-Encoding: XAXAX  ..............
       testing: 5  Accept-Language: XAXAX  ..............
       testing: 6  Accept-Charset: XAXAX   ..............
       testing: 7  Connection: XAXAX   ..............
       testing: 8  Referer: XAXAX  ..............
       testing: 9  Authorization: XAXAX    ..............
       testing: 10 From: XAXAX ..............
       testing: 11 Charge-To: XAXAX    ..............
       testing: 12 Authorization: XAXAX    ..............
       testing: 13 Authorization: XAXAX : foo  ..............
       testing: 14 Authorization: foo : XAXAX  ..............
       testing: 15 If-Modified-Since: XAXAX    ..............
       testing: 16 ChargeTo: XAXAX ..............
       testing: 17 Pragma: XAXAX   ..............
+ testing misc strings 17:
       testing: 1  User-Agent: XAXAX   ..............
       testing: 2  Host: XAXAX ..............
       testing: 3  Accept: XAXAX   ..............
       testing: 4  Accept-Encoding: XAXAX  ..............
       testing: 5  Accept-Language: XAXAX  ..............
       testing: 6  Accept-Charset: XAXAX   ..............
       testing: 7  Connection: XAXAX   ..............
       testing: 8  Referer: XAXAX  ..............
       testing: 9  Authorization: XAXAX    ..............
       testing: 10 From: XAXAX ..............
       testing: 11 Charge-To: XAXAX    ..............
       testing: 12 Authorization: XAXAX    ..............
       testing: 13 Authorization: XAXAX : foo  ..............
       testing: 14 Authorization: foo : XAXAX  ..............
       testing: 15 If-Modified-Since: XAXAX    ..............
       testing: 16 ChargeTo: XAXAX ..............
       testing: 17 Pragma: XAXAX   ..............
+ testing misc strings 18:
```

```
        testing: 1  User-Agent: XAXAX   ..............
        testing: 2  Host: XAXAX ..............
        testing: 3  Accept: XAXAX   ..............
        testing: 4  Accept-Encoding: XAXAX  ..............
        testing: 5  Accept-Language: XAXAX  ..............
        testing: 6  Accept-Charset: XAXAX   ..............
        testing: 7  Connection: XAXAX   ..............
        testing: 8  Referer: XAXAX  ..............
        testing: 9  Authorization: XAXAX    ..............
        testing: 10 From: XAXAX ..............
        testing: 11 Charge-To: XAXAX    ..............
        testing: 12 Authorization: XAXAX    ..............
        testing: 13 Authorization: XAXAX : foo  ..............
        testing: 14 Authorization: foo : XAXAX  ..............
        testing: 15 If-Modified-Since: XAXAX    ..............
        testing: 16 ChargeTo: XAXAX ..............
        testing: 17 Pragma: XAXAX   ..............
 + testing misc strings 19:
        testing: 1  User-Agent: XAXAX   ..............
        testing: 2  Host: XAXAX ..............
        testing: 3  Accept: XAXAX   ..............
        testing: 4  Accept-Encoding: XAXAX  ..............
        testing: 5  Accept-Language: XAXAX  ..............
        testing: 6  Accept-Charset: XAXAX   ..............
        testing: 7  Connection: XAXAX   ..............
        testing: 8  Referer: XAXAX  ..............
        testing: 9  Authorization: XAXAX    ..............
        testing: 10 From: XAXAX ..............
        testing: 11 Charge-To: XAXAX    ..............
        testing: 12 Authorization: XAXAX    ..............
        testing: 13 Authorization: XAXAX : foo  ..............
        testing: 14 Authorization: foo : XAXAX  ..............
        testing: 15 If-Modified-Since: XAXAX    ..............
        testing: 16 ChargeTo: XAXAX ..............
        testing: 17 Pragma: XAXAX   ..............
* Other tests:
* All tests done.


real    280m56.694s
user    0m13.597s
sys     0m14.529s
```

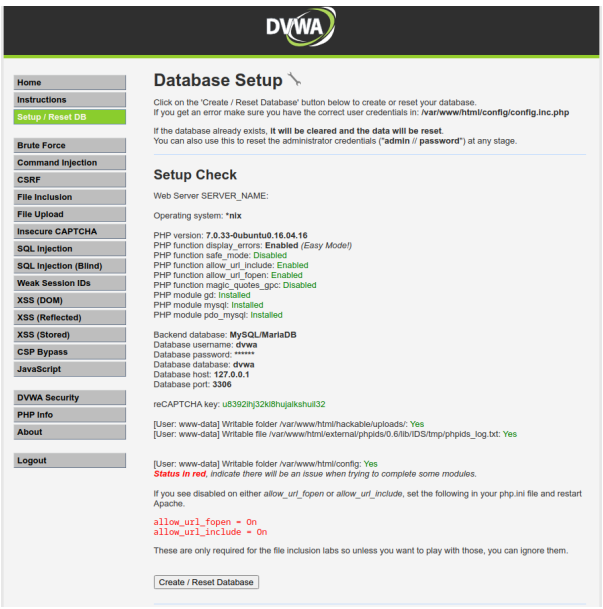
The tests took 4 hours and 40 minutes to run on older hardware.

4. Conclusion

In this other Article, I wrote up about using Doona, which is a fork of BED. http://www.securityhardening.com/library/Article36.pdf

The output shown in this paper looks very similar to Doona. The only thing missing is the vulnerability count at the end of each line. This tool (BED) runs faster than Doona on the same hardware against the same target system.

The Application, DVWA did not crash. The Admin page for DVWA looks like:



And it is still running like a pro.

My conclusion about all of this is, if you need a fast fuzzer, BED is a decent tool. If I need a thorough tool, I believe Doona has more to offer based on the length of time each tool takes. So in the end, it is a time trade off for accuracy.

5. Appendix

References

https://tools.kali.org/vulnerability-analysis/bed

https://www.blackarch.org/fuzzer.html