Cyberprobe

for version 0.90, 9 March 2017

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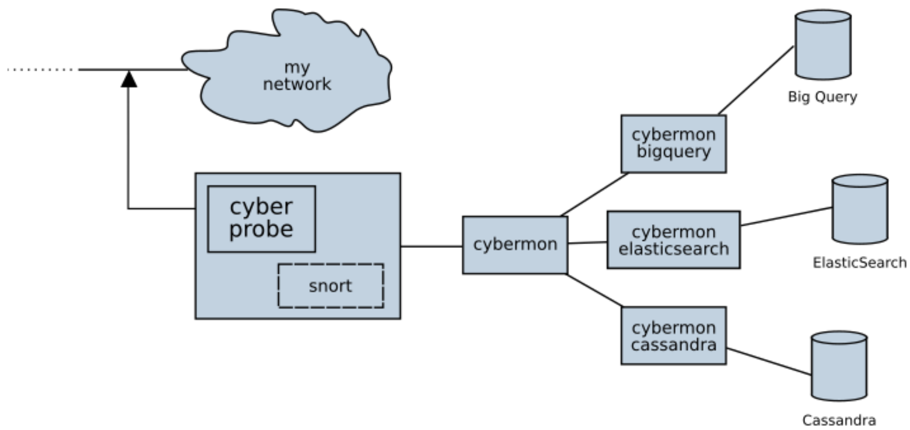
Cyberprobe

This is the manual for Cyberprobe (version 0.90, 9 March 2017).



Cyberprobe is a distrbuted architecture for real-time monitoring of networks against attack. This has applications in network monitoring, intrusion detection, forensic analysis, and as a defensive platform during an attack.

The software consists of a number of components, including:

- a probe, which collects data packets and forwards it over a network in standard streaming protocols.
- a monitor, which receives the streamed packets, decodes the protocols, and interprets the information.

These components can be used together or separately. For a simple configuration, they can be run on the same host, for more complex environments, a number of probes can feed a single monitor. For more detail, and to see where we are going, read the Chapter 7 [Architecture], page 56 page.

> **Note:** FIXME: This manual page is slightly out-of-date, and needs to cover the visualisation components.
>
> **Note:** FIXME: Architecture diagram needs an update.

1 Overview

Summary

Cyberprobe is a distrbuted architecture for real-time monitoring of networks against attack. The software consists of a number of components, including:

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- a monitor, which receives the streamed packets, decodes the protocols, and interprets the information.

These components can be used together or separately. For a simple configuration, they can be run on the same host, for more complex environments, a number of probes can feed a single monitor. For more detail, and to see where we are going, read the Chapter 7 [Architecture], page 56 page.

The probe, `cyberprobe` has the following features:

- The probe can be tasked to collect packets from an interface and forward any which match a configurable address list.
- The probe can be configured to receive Snort alerts. In this configuration, when an alert is received from Snort, the IP source address associated with the alert is dynamically targeted for a period of time. In such a configuration, the system will collect data from any network actor who triggers a snort rule and is thus identified as a potential attacker.
- The probe can optionally run a management interface which allows remote interrogation of the state, and alteration of the configuration. This allows dynamic alteration of the targeting map, and integration with other systems.
- The probe can be configured to deliver on one of two standard stream protocols.

The monitor tool, `cybermon` has the following features:

- Collects packets delivered in stream protocols.
- Decodes packet protocols in and raises events in near-real-time.
- Decoded information is made available to user-configurable logic to define how the decoded data is handled. A simple configuration language is used (LUA) and example configurations are provided to monitor data volumes, display data hexdumps, or stash the data in files.
- Packet forgery techniques are included, which allow resetting TCP connections, and forging DNS responses. This can be invoked from your LUA in order to fight back against attacks on your network.
- Supports IP, TCP, UDP, ICMP, HTTP and DNS protocols, currently.

The cybermon software is a bit of a work-in-progress at the moment, and needs more protocols added, but there's enough capability to be useful, and to demonstrate the value of this architecture.

The code is targeted at the Linux platform, although it is generic enough to be applicable to other UN*X-like platforms.

The easiest way to learn about the software is to follow our Quick Start tutorial.

Motivation

Cyberprobe started out as a research tool to study networked applications to find out what they were doing, as we all know how software suppliers sometimes like to add some "extras" to their software :). So, a simple tool to configure how packets are captured from a network was produced. But as you are probably aware, the biggest threat to the safety of your information is from outside of your network. Thus, the ability to trigger collection of packets upon detection of a Snort rule hit was added.

Snort is a powerful IDS system which studies packets on your network, analyses them against a set of signatures and creates logs and alerts. We felt there was a need to harness the Snort alerts, but use them to trigger collection and forwarding of packets from the address which caused the alert.

You may be asking why you'd want to use Cyberprobe? After all, monitoring networks with tcpdump and Snort and collecting alerts and packet data for analysis is a straightforward process for many networks. However, real-time analysis is not possible if everything is file based. Collecting the data and forwarding over the network to a central collection point allows for a much more "industrialised" approach to intrusion detection. If you detect an attack attempt, and then observe vast quantities of data leaving your network from the credit card accounts database, then you know you need to act quickly.

You need flexibility about how you monitor for network attacks. There isn't a one-size-fits-all solution. Attackers are ingenious in their approach to attacking your network, so you need to have a flexible, configurable monitoring tool to develop your defences.

Warning

There's a war coming... The enemy is resourceful, they can use your networks and systems as their own weapon. But with the right tools, you can prepare a defence. It's time to get ready for Cybermaggedon.

Revision history

Cyberprobe releases:

`0.90` NTP handling, DNS output format changed, robustness fixes in TCP handling.

`0.83` Point release, minor fixes.

`0.80` Added optional TLS support for packet streams to cyberprobe and cybermon. This change refactors the cybermon command line interface. See documentation for new command line options.

`0.79` Socket closure fix.

`0.76` Make UUIDs unique.

`0.74` Cassanda subscriber support.

`0.71` Fixes.

`0.70` Added ZeroMQ pub/sub support, with subscribers for ElasticSearch, Gaffer, Google BigQuery.

- `0.63` ElasticSearch integration brought up to latest ES verison. Cybermon Gaffer integration work completed to point of release.
- `0.62` Source-code updated to work with latest dependencies, operating systems and compiler versions. Early Gaffer integration.
- `0.61` Fixed HTTP crashing problem in cybermon.
- `0.60` IP address matching now permits specification of a mask. Documentation improved, regression suite added, a few unit tests starting to form.
- `0.55` Packages released for Debian, Fedora and Centos, documentation re-worked into info and man formats.
- `0.50` ElasticSearch integration improved to get a much tighter integration with Kibana for a network dashboard. Also bug-fixes for memory management / lock problems.
- `0.40` Now includes prototype STIX support: A TAXII server allows distrubution of threat information, and a TAXII client can read indicator information and store in a way that cybermon can use.
- `0.30` The build process now uses the GNU toolset. It detects the LUA interface and can compile against LUA 5.1 and 5.2. Successfully compiled on a MacBook!
- `0.25` Added SMTP and FTP capability. Also added a primitive mechanism to visualise network observations.
- `0.20` HTTP and DNS protocol capability. TCP reset and DNS packet forgery added. Major overhaul of the LUA language interface.
- `0.12` Cybermon utility is configurable using LUA.
- `0.11` Added basic cybermon utility.
- `0.10` Added management interface.
- `0.9` First release on SourceForge.

2 Obtaining the software

The code doesn't have many dependencies. Exotic dependencies are:

- Boost regex.
- Boost shared pointer.
- LUA - 5.1 or later.
- GCC C++ compiler and development support.
- `libpcap`.
- Expat (XML parser).
- `tcpdump` - not needed to build the software, but we use it in the tutorial.
- `telnet` - not needed to build the software, but we use it in the tutorial.
- `luafilesystem`, if using certain Lua configuration files.
- `luajson`, if using certain Lua configuration files.
- `lua-md5`, for MD5 hashing payloads.
- `ncurses`, needed for the command line admin utility.
- `readline`, needed for the command line admin utility.
- For STIX support, `libtaxii` and `stix` are Python modules made available at http://mitre.org which can be downloaded using `pip`.

There are a number of ways to obtain the software:

Download packages

The easiest way to obtain the software is to download the package for the operating system you are using. Packages are currently available for:

- Fedora 24, 64-bit.
- Debian Jessie, 64-bit.
- Ubuntu, 64-bit. FIXME: What version?

Downloads are available on the project page at http://github.com/cybermaggedon/cyberprobe/releases.

Fedora packages are installed using `yum`:

```
sudo dnf install <package>
```

Debian, Mint and Ubuntu packages are installed using `dpkg`:

```
sudo dpkg -i <package>
```

If there are dependency errors e.g. because you don't have some dependencies installed, you can install them thus:

```
sudo apt-get install -f
```

Install from source

Note: on many platforms, installing a package just adds the "run time" part of the code. In order to be able to compile code against the run time, you need to install a separate "developers kit" package. On Fedora, for instance, both `libpcap` and `libpcap-devel` are needed in order to be able to build this code from source.

Note also that `lua` packages can be a little strange: sometimes the package will exist in your distribution, at other times you need to install a utility called `luarocks` to install the package.

Source downloads are available on the project page at http://github.com/cybermaggedon/cyberprobe/releases, look for the `.tar.gz` file.

These files can be unwrapped, then configured:

```
tar xvfz cyberprobe-X.Y.tar.gz
cd cyberprobe-X.Y
./configure
make
sudo make install
```

`README.linux` provides some hints for Linux users. If installing on MacOS, read `README.mac`.

Installing from git

To checkout the latest code using git:

```
git clone http://git.code.sf.net/p/cyberprobe/code cyberprobe
```

To build, use:

```
autoreconf -fi
./configure
make
sudo make install
```

Powered by Github, project page is at http://cyberprobe.trustnetworks.com.

Docker repository

There are two Docker repositories containing the Cyberprobe distribution. See http://hub.docker.com/r/cybermaggedon/cyberprobe.

- `docker.io/cybermaggedon/cyberprobe`
- `docker.io/cybermaggedon/cybermon`

The only difference is the default command which is executed on running the container. Here are some container invocations you may find useful:

- Run `cyberprobe`. You will need to create a configuration file and map it in to the container.

  ```
  sudo docker -it --rm -v /etc/cyberprobe:/etc/cyberprobe_host \
    docker.io/cybermaggedon/cyberprobe \
    cyberprobe /etc/cyberprobe_host/cyberprobe.fg
  ```

- Run `cybermon`. The `cybermon` container exposes ports 9000 and 5555.

```
sudo docker -it --rm -p 9000:9000 -v \
  --net=host --privileged --cap-add=NET_ADMIN \
  docker.io/cybermaggedon/cybermon \
  cybermon /etc/cyberprobe/zeromq.lua
```

- Run `cybermon-cassandra`. You need to know the IP address of the host side of the Docker bridge network, and provide addresses of the Cassandra servers.

```
sudo docker -it --rm -v \
  docker.io/cybermaggedon/cybermon \
  cybermon-cassandra tcp://147.146.0.1:5555 \
  10.142.146.6,10.142.146.8
```

Running cyberprobe in a container makes the deployment easier, but it needs to run with elevated privileges in order to sniff the network, which reduces some of the advantages of running it in a container.

3 Quick start tutorial

3.1 Preparation

Build software

For installation, see Chapter 2 [Obtaining the software], page 5. There's a fair amount of development taking place in the git repository, so you probably want to get the a package, or use the latest release on the downloads page (`http://github.com/cybermaggedon/cyberprobe/releases`).

The compilation process compiles the following commands:

`cyberprobe`
: Packet capture.

`cybermon`
: Data analyser, analyses the data streams and reports events.

`etsi-rcvr`
: Test decoder for ETSI format data.

`cyberprobe-cli`
: Cyberprobe control command-line client.

`cybermon-bigquery`
: Pub/sub subscriber, delivers events to Google Bigquery.

`cybermon-cassandra`
: Pub/sub subscriber, delivers events to Cassandra.

`cybermon-elasticsearch`
: Pub/sub subscriber, delivers events to ElasticSearch.

`cybermon-gaffer`
: Pub/sub subscriber, delivers events to Gaffer.

If it installs / builds without errors, then it's time to start something up. If you have problems you can't resolve raise an issue at (`https://github.com/cybermaggedon/cyberprobe/issues`).

Establish network parameters

The simplest way to use cyberprobe is to use it on a Linux workstation, or in a virtual machine. Maybe you're using a Linux desktop now now? If so, you could use it to capture all the data going to/from the internet. This will be a static configuration in order to keep things simple. We'll do dynamic tracking later.

In the next few steps, you'll use `cyberprobe` to capture some data, on your workstation, and stream it to `etsi-rcvr` so that you know it's working. But first, you'll need to collect some information about your configuration.

You need to know the name of the network interface you are using. The command `/sbin/ifconfig` will show you all the network interfaces your machine knows about. e.g.

```
lo: flags=73<UP,LOOPBACK,RUNNING>  mtu 65536
        inet 127.0.0.1  netmask 255.0.0.0
        inet6 ::1  prefixlen 128  scopeid 0x10
        [etc.]

eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
        inet 192.168.1.80  netmask 255.255.255.0
        inet6 fe80::a60:6eff:fe81:7a75  prefixlen 64
        [etc.]
```

The lo interface is a loopback interface, and isn't really on the network, so ignore that. It's an interface that gets packets going to `127.0.0.1` and makes sure they end up handled by your workstation. Your interface is quite likely to be called something like eth0. The other thing you need to know is the IP address of your workstation. The IP address is associated with an interface, so in the above example, I can see I have an IP address `192.168.1.80`.

Note: on some networks (like mine) the IP address is allocated dynamically. In my case, the IP address is allocated by the broadband router. If things aren't working as you expect, you should check your IP address to check your workstation hasn't been allocated a new, different address. In my case, I can tell the broadband router to permanently allocate a particular IP address to this workstation, so that it won't change.

3.2 Using `cyberprobe`

Starting cyberprobe with a configuration file

The source code contains a file `config.xml` which is a good template for any configuration you're going to build. However, for the purpose of this discussion, let's start from scratch. In order to do anything useful, there are three essential elements to a cyberprobe configuration file: interfaces, targets and endpoints. The system won't do anything useful without those three configuration elements defined. Let's start with a very simple configuration.

Using your favourite text editor, create a text file, say `c.xml` with the following contents:

```
<?xml version="1.0" encoding="ISO-8859-1"?>

<configuration>

  <interfaces>
    <interface name="eth0"/>
  </interfaces>

  <targets>
  </targets>

  <endpoints>
  </endpoints>

</configuration>
```

Note: You should replace the `eth0` string with the name of your network interface. Remember? We discovered that when playing with the `ifconfig` command.

We're ready to roll. We need to run as a privileged used because cyberprobe captures data off the network interface. So, running as root, you need to locate the place where you compiled the code, and run `cyberprobe` giving it the name of the configuration file you just created:

```
cyberprobe c.xml
```

If everything goes to plan, you should see the following output:

```
Capture on interface eth0 started.
```

If you see an error message, the obvious two things to check are:

- Did you name a network interface correctly? See `ifconfig` discussion above.
- Are you running as a privileged user?

If you see no output at all, check that your configuration file is correct.

Once you are seeing the "Capture on interface eth0" line, then you've achieved success in this step, and are ready to move on.

If you have everything working, there's one thing to note before moving on: cyberprobe treats a broken configuration file the same as an empty configuration file. With cyberprobe running, edit the configuration file, and delete the query ('`?`') prefix in the first line, so that it looks like this:

```
<xml version="1.0" encoding="ISO-8859-1"?>
```

You've now broken the configuration file. It's not valid XML any more, so the parsing fails. You should see this output from `cyberprobe`:

```
Capture on interface eth0 stopped.
```

If you repair the damage to the configuration file, everything will start working again. The lesson here is: If you find that `cyberprobe` won't recognise any resources, it's likely that your configuration file is invalid. The utility `xmlwfx` can be useful to check that an XML configuration file is valid, if you're not getting the results you expect.

Adding a target

We have `cyberprobe` running, but it isn't doing anything useful. Remember, I said that a useful configuration consists of three minimal elements: interfaces, targets and endpoints? Well, currently we only have interfaces defined. That means that `cyberprobe` is capturing packets off of the network, but throwing them away.

Let's add a target. Edit the targets block of the configuration file. We need an entry describing the IP address of my workstation. Remember? We discovered that with the ifconfig command earlier? Instead of `192.168.1.80` use the IP address of your workstation.

```
<targets>
  <target address="192.168.1.80" liid="123456"/>
</targets>
```

If successful, you should see new output from `cyberprobe`:

```
Added target 192.168.1.80 -> 123456.
```

The target configuration allows specification of IPv4 and IPv6 addresses, and addresses can include a mask, which allows IP address matching to be applied in a wildcard configuration. See Section 6.2 [cyberprobe configuration], page 28

At this step, we're capturing packets, spotting target addresses, but as there's no endpoint defined there's still nowhere to send the data. So, this is still a useless configuration. On to the next step...

Adding an endpoint

Adding an endpoint to the configuration file will define a place where the captured data is sent. Before adding an endpoint, let's make sure there's something ready to receive the data.

In a separate terminal window, navigate to the `cyberprobe` build, and run:

```
etsi-rcvr 10000 | tcpdump -n -r -
```

The `etsi-rcvr` program opens a TCP port listening on port 10000 for a stream of ETSI data, and on standard output, writes the IP packets it sees in PCAP format. The tcpdump command receives this PCAP data, and outputs packet summaries.

If that starts successfully, the next step is to plumb a connection from `cyberprobe` to `etsi-rcvr`.

Next, edit the configuration file, and edit the endpoints block to deliver packets to a local service on port 10000:

```
<endpoints>
  <endpoint hostname="localhost" port="10000"
      transport="tcp" type="etsi"/>
</endpoints>
```

If that worked, you should see `cyberprobe` start the endpoint:

```
Added endpoint localhost:10000 of type etsi
```

Hopefully you'll start to see some output from tcpdump...

Capturing data

At this step, `cyberprobe` should be forwarding an network traffic your workstation generates to the tcpdump command, so that you see data. Any average workstation is generating network traffic all the time, so you won't need to do anything. But if you see nothing, you can do something like, visit the Google home page in a browser on your workstation. You should see something like this pouring from the tcpdump.

```
18:54:24.376838 IP 192.168.1.80.54249 > 212.58.244.71.http: Flags [P.],
 seq 1:673, ack 1, win 115, options [nop,nop,TS val 129851063 ecr 33669
55869], length 672
18:54:24.390768 IP 212.58.244.71.http > 192.168.1.80.54249: Flags [.],
ack 673, win 124, options [nop,nop,TS val 3366955882 ecr 129851063], le
ngth 0
18:54:24.392909 IP 212.58.244.71.http > 192.168.1.80.54249: Flags [P.],
 seq 1:1796, ack 673, win 124, options [nop,nop,TS val 3366955884 ecr 1
29851063], length 1795
```

At this step, it's worth having a quick play with the reconnection mechanism. Stop and start `etsi-rcvr`, and you'll see that `cyberprobe` reconnects automatically:

```
ETSI LI connection to localhost:10000 failed.
Will reconnect...
ETSI LI connection to localhost:10000 established.
```

We don't guarantee zero data loss on a reconnect.

3.3 Management interface

At this step, we'll setup a control port, and use it modify the configuration of `cyberprobe`.

First step is to modify the configuration file to include this line, just after the `<configuration>` line:

```
<control port="8888" username="admin" password="mypassword"/>
```

That declares that a management service needs to be run on port 8888. The authentication details are provided too. You should see this output from `cyberprobe`:

```
Starting control on port 8888
```

That's good! Now need to connect and interrogate the targets list: I use telnet to connect, the auth command to authenticate, and the target command to see a list of commands.

```
$ telnet localhost 8888
Trying 127.0.0.1...
Connected to localhost.
Escape character is '^]'.
auth admin mypassword
200 Authenticated.
targets
201 Targets list follows.
25
123456:ipv4:192.168.1.80/32
```

I can use the help command to see the full list of commands permitted. There are commands for changing the address target list:

```
targets
201 Targets list follows.
25
123456:ipv4:192.168.1.80
remove_target ipv4 192.168.1.80
200 Removed target.
add_target 654321 ipv4 192.168.0.0/16
200 Added target.
```

The interface isn't pretty, but you get the idea. You can change almost everything that you can manage by changing the configuration file.

Note: The the management interface changes the active state of `cyberprobe` but it doesn't change the configuration file. So, configuration changes made through the management interface are 'lost' when you restart `cyberprobe`.

Note also that you may get some weird results if you use the configuration file AND the control interface to manage the same resources, so you probably don't want to do that.

The `cyberprobe-cli` command can be used to access the management interface but provides a (slightly) nicer `readline` interface, and has auto-completion. Usage is of the form

```
cyberprobe-cli host port
```

Once you're in, you can type help to get help, or press TAB for auto-completion of commands.

3.4 Integration with snort

In this step, we'll add the excellent IDS, Snort to the mix. If you don't know Snort, it scans network traffic for patterns, and can take various actions when those patterns are discovered. It is typically used to detect network attacks, and the Snort folks maintain a huge collection of patterns that will identify known network attacks. The Snort team maintain the project at http://www.snort.org.

If you want to try out the Snort integration, you need to head over to the Snort home page, download and install Snort. Or install the appropriate package with your distribution.

Once you have it installed, to simplify things, you'll want to put a rule in place that will definitely identify things on your network. The easiest way is to add a local rule that identifies your workstation. First of all, you'll want to make sure your Snort configuration file (probably `/etc/snort/snort.conf`) loads a local rules file. So, it should contain something like this:

```
# site specific rules
include $RULE_PATH/local.rules
```

Then, to identify your workstation, add a rule like this to your local rules file (probably `/etc/snort/rules/local.rules`):

```
alert tcp 192.168.1.80 any -> any 80 (msg:"Web";
classtype:misc-activity;sid:200; rev:1;)
```

`cyberprobe` itself needs to be configured to receive Snort alerts. You do that by adding some configuration, just after the <configuration> line:

```
<snort_alert socket="/var/log/snort/snort_alert" duration="60"/>
```

That says, Snort alerts will result in dynamic collection of data for 60 seconds from identification. While you're in the configuration file, you can remove the static IP address target line. Find this line and delete it:

```
<target address="192.168.1.80" liid="123456"/>
```

`cyberprobe` should respond:

```
Removed target 192.168.1.80 -> 123456.
Start snort alerter on /var/log/snort/snort_alert
```

Now I can run Snort in IDS mode. Snort needs to run as 'root':

```
snort -i eth0 -A unsock -N -l /var/log/snort/ -c /etc/snort/snort.conf
```

Thanks to our Snort rule, when our workstation generates network data, Snort will detect it, trigger our rule, and alert `cyberprobe`. You should see `cyberprobe` say:

```
Hit on signature ID 200, targeting 192.168.1.80
```

Also, once the rule is triggered, you should see evidence of packet data from the `tcpdump` command, as before. `cyberprobe` causes the targeting to time out after a period of time. If further alerts are seen, the targeting lifetime is targeted. If no further alerts are seen the IP address targeting is deleted. If you can convince your workstation to stop creating network data, by e.g. not using it for a minute or so, then you should see the rule time out:

```
Stopped targeting on 192.168.1.80
```

In practice this may be harder than you think, as workstations generate network traffic all the time. You may have to turn off your email clients and close the web browse. Your attempt to silence your workstation may be further thwarted by the operating system checking for patches without you knowing.

Introducing a delay

Your Snort integration suffers from a particular problem now. The time taken for Snort to inspect some packets, generate an alert and for `cyberprobe` to get the IP address targeted is not zero. It is hard to measure, but it is going to be a significant chunk of a millisecond. The problem is that by the time `cyberprobe` is targeting the IP address, the network attcker's packets have long gone. The result is, that while `cyberprobe` is now targetting the attacker, it won't capture the original network attack.

Our solution is to introduce a packet delay in `cyberprobe`. The packets entering `cyberprobe` are kept in a time-delay queue and are processed once that delay expires. You can configure a delay, by putting the delay attribute in an interface specfication. e.g.

```
<interfaces>
  <interface name="eth0" delay="0.2"/>
</interfaces>
```

0.2 second should be plenty enough. You should be able to see this delay in action: When you generate network traffic, you should be able to see the delay between network activity taking place, and the corresponding burst of activity from tcpdump.

At this point, you've completed the guided tour of `cyberprobe`, the packet capture tool. If that's all you need, the rest of the tutorial will probably have less interest to you: In the following steps, we'll start to analyse and act on the captured data.

3.5 Using `cybermon`

Introducing `cybermon`

The previous 9 steps have all been about `cyberprobe`. If you've got this far successfully, you pretty much know all there is to know about `cyberprobe`. It is time to start doing something more useful with all that data you are capturing. In this step we'll start up `cybermon` and look at the data.

Remember that `etsi-rcvr` command you started in step [Adding an endpoint], page 11? Stop that, and start `cybermon`. Two arguments are needed: A TCP port number to receive the data on, and a configuration which tells it what to do. A number of configuration files are bundled in with the source code, there should be a basic one called `monitor.lua` which is now installed in the etc directory, depending on where you installed the software:

```
cybermon 10000 /usr/local/etc/cyberprobe/monitor.lua
```

Now when you generate network traffic, some of the traffic will be presented in a reasonably intelligent form. For example, I do a naming service lookup for `www.google.com`...

```
host -t a www.slashdot.org
```

The DNS protocol is parsed, and presented in a human readable form. I can see the request, and the response:

```
SNORTc0a80150: 192.168.1.80:54633 -> 192.168.1.1:53. DNS query
    Query: www.slashdot.org

SNORTc0a80150: 192.168.1.1:53 -> 192.168.1.80:54633. DNS response
    Query: www.slashdot.org
    Answer: www.slashdot.org -> 216.34.181.48
```

I see the query travelling from my workstation to the broadband router, and then the response from the broadband router contains an answer field mapping the name to an address. HTTP protocols are also decoded. Get the Slashdot home page...

```
wget -O- 'http://www.slashdot.org/'
```

...and amongst all the other stuff, you see the HTTP request and response...

```
SNORTc0a80150: 192.168.1.80:34284 -> 216.34.181.45:80. HTTP GET request
    URL /
    Connection: Keep-Alive
    User-Agent: Wget/1.14 (linux-gnu)
    Host: slashdot.org
    Accept: */*

SNORTc0a80150: 216.34.181.45:80 -> 192.168.1.80:34284. HTTP response 200
OK
    URL http://slashdot.org/
    Connection: keep-alive
    Content-Length: 113468
    Date: Mon, 26 Aug 2013 13:13:25 GMT
    Age: 17
    X-Varnish: 1493567531 1493567417
    X-XRDS-Location: http://slashdot.org/slashdot.xrds
    Cache-Control: no-cache
    Vary: Accept-Encoding
    SLASH_LOG_DATA: shtml
    Pragma: no-cache
    Content-Type: text/html; charset=utf-8
    Server: Apache/2.2.3 (CentOS)
```

Trying other configuration files

In the previous step, you started `cybermon` with the monitor.lua configuration file. Have a play with a couple of the others. Configuration file hexdump.lua produces little hex dumps of things like HTTP bodies:

```
cybermon 10000 /usr/local/etc/cyberprobe/hexdump.lua
```

Configuration file `dump.lua` causes `cybermon` to dump the information to files in the data directory.

```
mkdir data
cybermon 10000 /usr/local/etc/cyberprobe/dump.lua
```

The `quiet.lua` configuration file does nothing. It may be a good place to start hacking your own configuration file. Which is exactly what we'll do in the next step.

3.6 Writing your own configuration file

Now, take a copy of the `quiet.lua` configuration file, and have a look at it. It consists of a bunch of functions written in the LUA language. LUA is a lightweight scripting langauge which is really good as a configuration language. For example, this function is called when a TCP connection is made:

```
observer.connection_up = function(context)
end
```

And this function is called when an HTTP response is observed:

```
observer.http_response = function(context, code, status, header, url,
                                  body)
end
```

Let's get hacking! The header parameter is a LUA table which contains key/value pairs from the header. The url parameter contains the full URL of the response. The body parameter contains the payload body as an empty string. Let's start simple:

```
observer.http_response = function(context, code, status, header, url,
                                  body)
  print(url)
end
```

Then run that up...

```
cybermon 10000 my.lua
```

Now, do some web browsing, and you should see a list of URLs flying past. Each web page typically consists of several HTTP requests, but you should be able to see the URLs associated with all of the web pages you visit. Let's tart that up a little more:

```
-- This function is called when an HTTP response is observed.
observer.http_response = function(context, code, status, header, url,
                                  body)

  -- Take first 40 characters of URL
  local u = url:sub(1,40)

  -- Get Content-Type (first 20 characters)
  local ct
  ct = ""
  for key, value in pairs(header) do
    if key:lower() == "content-type" then
      ct = value:sub(1,20)
    end
  end
```

```
  io.write(string.format("%-40s %-20s %d\n", u, ct, #body))

end
```

That basically outputs three columns: The URL (truncated to 40 characters), the body content type (truncated to 20 characters) and the HTTP response payload length. Here's what I get from visiting Slashdot:

```
http://widget-cdn.rpxnow.com/manifest/sh text/javascript;char 42980
http://slashdot.org/                     text/html; charset=u 40105
http://ad.doubleclick.net/adj/ostg.slash text/javascript; cha 5625
http://pagead2.googlesyndication.com/pag application/x-shockw 33347
http://ad.doubleclick.net/adj/ostg.slash text/javascript; cha 540
http://ad.doubleclick.net/adj/ostg.slash text/javascript; cha 42
http://ad.doubleclick.net/adj/ostg.slash text/javascript; cha 452
http://pagead2.googlesyndication.com/pag                      0
```

Forging a TCP reset

So far, this has just been monitoring. It's time to add data to the network! From the LUA functions, there are a couple of functions available which allow you to put some packets back onto the network.

But first... there's a problem. You remember in step 9, we added a delay? That's not going to work with packet forgery, because by the time we've forged a packet and sent it on to the network, it's too late. So, we need to change our interface back so that there's no delay on the interface. That means, we're monitoring network data, but we'll miss the original attack which triggered a Snort alert.

```
<interface name="eth0" delay="0.0"/>
```

Once you have this code working, you might be able to mess with the delay parameter to see if you can pick a low-latency value that works for you. On my network, the value 0.02 is low enough to allow a response to allow packet forgery to work. Any higher, and the forged packets are too late to beat the real packets.

The LUA interface passes a context variable to many of the LUA functions, which gives access to `cybermon` information and the packet forgery functions. In this step, we're going to forge a TCP reset on any connections which are from or to port 80. Hack the configuration file:

```
observer.connection_up = function(context)

    -- Get TCP ports.
    local cls, src_addr, dest_addr
    cls, src_addr = context:get_src_addr()
    cls, dest_addr = context:get_dest_addr()

    -- check if it is port 80.
    if not((src_addr == "80") or (dest_addr == "80")) then
      -- Ignore non-HTTP traffic
      return
    end
```

```
        -- TCP reset
        print("Reset on HTTP connection.")
        context:forge_tcp_reset(context)

    end
```

Now before we go any further, `cybermon` needs to run as root in order to use either of the packet forgery functions. Packet forgery needs access to the raw IP socket layer, which is a privileged operation. Start that up:

```
cybermon 10000 my.lua
```

Now start web browsing, and you should see a bunch of "Reset on HTTP connection" messages. Also, you'll see a page saying "The connection was reset" in your web browser. That's a fairly anti-social configuration to run on any network. See the `forge-reset.lua` example for a more useful configuration. It disrupts network traffic going to/from an SSH server which isn't from your administration workstation.

On any network with an SSH service open to the outside world, you might want to use firewall rules to prevent access to the SSH service from addresses outside of your network, but you could use `cybermon` as a belt-and-braces protection mechanism.

Another example is where you know the user community on your network is being targeted by phishing emails. Your first step is to try to get the phishing emails out of their inboxes, getting your email provider to filter the attacks. But a backup attack would be to make sure your users can't get to the phisher's web site. The http_request function allows us to reset requests going to a particular web site.

```
-- This function is called when an HTTP request is observed.
observer.http_request = function(context, method, url, header, body)

    if header["Host"] == "example.org" then
      print("Reset on HTTP request")
      context:forge_tcp_reset(context)
    end

    if header["Host"] == "www.example.org" then
      print("Reset on HTTP request")
      context:forge_tcp_reset(context)
    end

end
```

Forging a DNS response

In this step, we'll detect a particular DNS request, and forge a response. First of all, you'll need to familiarise yourself with host which is a useful DNS test tool. e.g.

```
$ host -t a example.org
example.org has address 93.184.216.119
```

The `example.org` name has been resolved to a particular IP address. Let's hack the DNS request function in my.lua:

```
-- This function is called when a DNS message is observed.
observer.dns_message = function(context, header, queries, answers, auth,
                                add)

  -- Check my assumptions.  Need a DNS query request, with one query,
  -- name is example.org, type 'A', class 'IN'.
  if header.qr == 0 and #queries == 1 and
    queries[1].name == "example.org" and queries[1].type == 1 and
    queries[1].class == 1 then

    -- Send a fake response

    -- Set query/response flag to 'response'
    header.qr = 1

    -- 1 answer
    answers = {}
    answers[1] = {}
    answers[1].name = "example.org"
    answers[1].type = 1
    answers[1].class = 1
    answers[1].rdaddress = "1.2.3.4"

    -- 1 answer
    header.ancount = 1

    io.write("Forging DNS response!\n")

    context:forge_dns_response(context, header, queries, answers,
                               {}, {})

  end

end
```

So, this example, checks that the query is one we want to mess with. If it is, we turn the query structures into response structures, and hand them back to `cybermon` to do a forgery. The above example forges the address `1.2.3.4`. Start up `cybermon` with the script:

```
cybermon 10000 my.lua
```

If everything is working your host command will show a different result:

```
$ host -t a example.org
example.org has address 1.2.3.4
```

DNS forgery has applications in blocking access to a phishers resources on the internet, you might want to redirect your users to an address which is inside your network.

The Section 6.8 [cybermon configuration], page 36 documentation details the LUA interface in detail if you want to find out what else you can do in your LUA code.

3.7 Visualisation

This is the most incomplete part of Cyberprobe. Look at this part as demonstrating what might be possible. If you find this interesting, and feel you could turn this into something more impressive, well... there's a git check-in with your name on.

Storing observations

Now we need somewhere to store the observations which cybermon discovers. There are many candidates for a storage repository, but my favourite for this sort of scenario is the excellent ElasticSearch (http://www.elasticsearch.org/). It is flexible, offers a huge amount of functionality, and is incredibly simple to interface with, thanks to its JSON API. So, your next action is to head over to the download page (http://www.elasticsearch.org/download/) and get hold of the latest version. I'm using version 2.3.5 to build this tutorial but the ElasticSearch API has proven hugely stable, so should work with the latest.

Having downloaded the latest version, you unpack it, and run it e.g.

```
tar xvfz elasticsearch-2.3.5.tar.gz
cd elasticsearch-2.3.5
bin/elasticsearch
```

One brilliant thing about ElasticSearch is that it needs almost no configuration to get an instance started. You will need to make one configuration change to ElasticSearch if there are other instances running on your network: you need need to change cluster.name to some unique string in config/elasticsearch.yml, otherwise your ElasticSearch instance might join another cluster on your network, which could complicate things.

You can check you have ElasticSearch up and running using a command such as this:

```
wget -q -O- http://localhost:9200
```

The response will look something like this:

```
{
  "name" : "Ellie Phimster",
  "cluster_name" : "elasticsearch",
  "version" : {
    "number" : "2.3.5",
    "build_hash" : "90f439ff60a3c0f497f91663701e64ccd01edbb4",
    "build_timestamp" : "2016-07-27T10:36:52Z",
    "build_snapshot" : false,
    "lucene_version" : "5.5.0"
  },
  "tagline" : "You Know, for Search"
}
```

Once ElasticSearch is running, you can get cybermon to load observations into it by using the db.lua configuration file. So if you're continuing the tutorial, you can stop cybermon, and run:

```
cybermon 10000 /usr/local/etc/cyberprobe/db.lua
```

After some network data has been observed, you should be able to see results loaded into ElasticSearch using the following command:

```
es=localhost:9200
curl -s -XPOST \
  "http://$es/cyberprobe/observation/_search?pretty=true" -d '
{
  "query" : {
    "match_all": {}
  }
}
'
```

You should see some stuff which looks like data scrolling past on the screen. If your response looks like the following result, that's not so good, as it means there are no results. See `hits.total`? Zero means no results.

```
{
  "took" : 1,
  "timed_out" : false,
  "_shards" : {
    "total" : 5,
    "successful" : 5,
    "failed" : 0
  },
  "hits" : {
    "total" : 0,
    "max_score" : null,
    "hits" : [ ]
  }
}
```

If you see a lot of information scrolling past on the screen, that's good.

The `db.lua` configuration file maps the `cybermon` observations into a form which is appropriate to store in ElasticSearch. Each observation is stored with a 1 hour time-to-live, to the information is not stored for long.

Visualising observations

Having loaded the observations into ElasticSearch, it's easy to do some visualisation with Kibana. Kibana is a brilliant, user-configurable dashboard package designed to sit on ElasticSearch. The dashboard runs in your browser.

First thing to do is to download and unpack Kibana. Kibana is managed by the ElasticSearch people, download page is at http://www.elasticsearch.co/downloads/kibana.

Unpack and execute:

```
tar xvfz kibana-4.5.4-linux-x64.tar.gz
cd cd kibana-4.5.4-linux-x64
bin/kibana
```

Kibana starts on port 5601, so point your browser at e.g. http://localhost:5601

and hopefully you see Kibana's "Welcome to Kibana" screen. Read the Kibana tutorial and start playing with the data.

3.8 Threat indicators using STIX

We've been experimenting with an open model for describing cyber threats. STIX is a community-driven effort to standardise a model for cyber theat information. TAXII defines a set of services for distributing STIX information. There's some support in `Cyberprobe`, but you should know that this is very prototype at the moment.

This is what we've got so far:

- There's a simple CSV file format we've created to describe cyber threats. This is just for convenience.
- A script, `stix-create` which reads the above configuration file, and converts into a STIX document containing Indicator objects.
- A script, `taxii-server` which acts as a very simple TAXII server, serving up STIX documents.
- A script, `taxii-client` which connects to a TAXII server, gets STIX documents and dumps some stuff out.
- A script `taxii-sync-json` which connects to a TAXII server, gets STIX documents, massages the whole lot into a single JSON form, and dumps that to a file. This is intended to be used with the `stix+db.lua` and `stix+alert.lua` configuration files.
- A configuration file for `cybermon` which reads the JSON threat information and reports when theats are observed.

Before taking this any further, you need to have Python installed, along with various dependencies (`pyOpenSSL`, `libtaxii` and `stix`). The easiest way to install the dependencies is to install `pip`, and issue this command:

```
sudo pip install libtaxii pyOpenSSL stix
```

A STIX document service

The installation bundle includes a couple of CSV files containing some fictional cyber theats. Search for `example1.txt` and `example2.txt`. They may be in `/usr/local/share/doc/cyberprobe` once you've installed everything. You need to create a data area, and convert these files into STIX ready for serving:

```
mkdir /tmp/stix
cd /tmp/stix
mkdir -p data/default
stix-create /usr/local/share/doc/cyberprobe/example1.txt \
        data/default/1 -i ex:1
stix-create /usr/local/share/doc/cyberprobe/example2.txt \
        data/default/2 -i ex:2
```

Check that you have two new XML files in data/default directory. If they're there, you're ready to start a STIX server. This will run on port 8080, so you'll need to use a different port number if you don't like this one. It's important that this is run from the directory where you just created the data directory.

```
taxii-server --port 8080
```

If that works, use the test client to communicate:

```
taxii-client --port 8080
```

And you should see some stuff that looks like cyber threat information dumped on the screen.

Deploying theat information to `cybermon`

Now, we use `taxii-sync-json` to fetch the STIX information in a JSON form I can easily ingest into the LUA code:

```
taxii-sync-json --port 8080
```

This should create a JSON file called `stix-default-combined.json`.

Finally, stop any running `cybermon` processes, and run `cybermon` with a configuration file which reads the JSON file.

```
cybermon 10000 /usr/local/etc/cyberprobe/stix+alert.lua
```

Now, this produces no output, except when activity which hits on a cyber threat is observed. If you used my sample data, then this activity should trigger a theat:

```
wget -q -O- http://www.malware.com/malware.dat
```

I should just say at this point, I have no idea if the `malware.com` site is dodgy or not, it just seems to redirect to Wikipedia. Hope they don't mind us using them for this test.

If this works, you should see the following output:

```
DNS query for www.malware.com, hits example1:5 (Hostname of malware
server)!
DNS query for www.malware.com, hits example1:5 (Hostname of malware
 server)!
DNS response for www.malware.com, hits example1:5 (Hostname of malware
 server)!
DNS response for www.malware.com, hits example1:5 (Hostname of malware
 server)!
HTTP request to http://www.malware.com/malware.dat, hits example1:7 (URL
 of a page serving malware)!
HTTP request to www.malware.com, hits example1:5 (Hostname of malware
 server)!
HTTP response from http://www.malware.com/malware.dat, hits example1:7
 (URL of a page serving malware)!
```

This hits on a number of theat indicators. The hostname www.malware.com is present in a theat indicator, and it is detected in the HTTP request, and both the DNS query and response. Also, the URL `http://www.malware.com/malware.dat` is in a threat indicator and it is detected in both the HTTP request and response.

The `stix+alert.lua` configuration file updates its configuration if the JSON configuration file has changed. So, you can do a round-trip update by changing the input files, re-running stix-create, using `taxii-sync-json` to fetch the updates, and all without stopping the monitoring.

The `stix+db.lua` configuration file generates ElasticSearch events as `db.lua` does, but it also adds indicator detection information to the events. If you use `stix+db.lua`, with the Kibana dashboard, the "Indications" table on the right hand side of the dashboard will show detected indicators.

Conclusion

All done, I hope you enjoyed the tutorial! Any comments on the software, or tutorial itself are very welcome! Positive, or negative, we want to hear how you found the experience.

4 Running cyberprobe/cybermon

The `cyberprobe` and `cybermon` utilities are used as a pair to analyse network data. The `cyberprobe` component is used to capture data and forward to `cybermon`. When running on a network, you can decide to run several `cyberprobe` deployments into a single `cybermon`. Or run a `cybermon` process everywhere you run a `cyberprobe`.

Once you have decided your checklist, your setup checklist for using `cyberprobe` and `cybermon` consists of:

- Install the software, see Chapter 2 [Obtaining the software], page 5.
- If you are going to run `cyberprobe`, provide the appropriate configuration in file `/usr/local/etc/cyberprobe.cfg`. The standard installation will install a template at this location. See Section 6.2 [cyberprobe configuration], page 28 on managing this configuration file. Make sure that the configuration file includes the delivery address of the appropriate `cybermon`.
- If you are going to run `cybermon`, provide the appropriate configuration in file

  ```
  /usr/local/etc/cyberprobe/cybermon.lua.
  ```

  The standard installation does not create a file at this location, and you should create one. You can copy an example from the `/usr/local/etc/cyberprobe` directory. Use `/usr/local/etc/cyberprobe/zeromq.lua` if you want to use pub/sub delivery. See Section 6.8 [cybermon configuration], page 36 for more information on constructing the configuration file. See Section 6.9 [cybermon example configurations], page 41 for descriptions of the example configuration files.
- The installation installs appropriate `systemd` configuration, and you can enable boot-time starting of `cyberprobe` or `cybermon` by using either or both of these commands:

  ```
  systemctl enable cyberprobe
  systemctl enable cybermon
  ```

  Once enabled, you can reboot, or immediately start the processes using either or both of these commands:

  ```
  systemctl start cyberprobe
  systemctl start cybermon
  ```

5 The pub/sub infrastructure

5.1 Pub/sub overview

Events from `cybermon` can be delivered to a pub/sub mechanism which allows subscribers to connect and disconnect without disrupting delivery to other subscribers. The pub/sub mechanism used is ZeroMQ, which is a simple non-persistent, broker-less mechanism.

In order to use this mechanism, you need to ensure you have configured `cybermon` appropriately. This is normally done by copying the `zeromq.lua` to `cybermon.lua` in directory `/usr/local/etc/cyberprobe/`. prior to executing `cybermon`. Once running, `cybermon` will publish all events to it's publisher port on TCP port 5555.

ZeroMQ allows subscribers to be started and stopped without affecting the delivery of events to other receivers. That is, you can start `cybermon` with no subscribers, discarding data, and introduce subscribers later.

5.2 The Cassandra subscriber

This subscriber writes data to a Cassandra store in a schema useful for graph analysis.

The schema is experimental, but see https://github.com/cybermaggedon/cassandra-redland for the tooling I'm using.

On the command-line you need to tell the subscriber the location of the Cassandra contact points e.g.

```
cybermon-cassandra tcp://localhost:5555 cas1,cas2,cas3
```

See Section 6.15 [cybermon-cassandra invocation], page 46.

5.3 The ElasticSearch subscriber

This suscriber extracts events from pub/sub and formats them for delivery to ElasticSearch. The only piece of information you need is the ElasticSearch base URI, which is used as a command-line parameter e.g.

```
cybermon-elasticsearch tcp://localhost:5555 http://es-host1:9200
```

See Section 6.12 [cybermon-elasticsearch invocation], page 44.

5.4 The Gaffer subscriber

Gaffer is an experimental graph database built on top of Accumulo, Zookeeper and Hadoop. This subscriber writes IP-to-IP communication nodes in the graph. If you want to use this, get familiar with Gaffer. Gaffer is developed at https://github.com/gchq/Gaffer, and I have Gaffer containers here: https://hub.docker.com/r/cybermaggedon/wildfly-gaffer/.

On the command-line you need to tell the subscriber the location of the Gaffer REST API. e.g.

```
cybermon-gaffer tcp://localhost:5555 \
    http://gaffer-host1:8080/example-rest/v1
```

The Gaffer subscriber is intended to work with a Gaffer schema which is `/usr/local/share/doc/cyberprobe/gaffer-schema.json`.

See Section 6.14 [cybermon-gaffer invocation], page 45.

5.5 The Google BigQuery subscriber

Google BigQuery is a cloud data storage mechanism which is part of the Google Cloud Platform, available to Google Cloud subscribers.

BigQuery is a 'big data' relational style database, with a query language familiar to SQL users.

To use BigQuery, you need to get a private key file in private JSON format from the cloud interface, and store this at `/usr/local/etc/cyberprobe/private.json`. One way to do this is to go to the IAM interface and create a use with BigQuery access, and download the private JSON file.

You need to also to create the BigQuery dataset. Call it '`cyberprobe`'. The BigQuery table is created automatically when the subscriber is started.

If the key is installed at the above location, you do not need to provide any further parameters on the command line. Just run:

```
cybermon-bigquery
```

> **Note:** FIXME: Document the schema. The easiest way to see the schema is to use this subscriber, and view the schema in the Google BigQuery interface.

See Section 6.13 [cybermon-bigquery invocation], page 44.

5.6 The debug monitor subscriber

The `cybermon-monitor` subscriber is a subscriber which takes events and writes human-readable output on standard output. This is a useful means to verify that `cyberprobe`, `cybermon` and pub/sub are configured correctly.

See Section 6.11 [cybermon-monitor invocation], page 44.

6 Reference

6.1 cyberprobe invocation

`cyberprobe` is a network monitor which collects packets which match an IP address list. The packets collected are streamed using network streaming protocols. The IP address match list can be statically conqfigured (in a configuration file), can be dynamically changed using a management interface, or can be dynamically changed as a result of snort alerts. Synopsis:

```
cyberprobe configuration-file
```

- *configuration-file* is the name of an XML configuration file. See Section 6.2 [cyberprobe configuration], page 28.

`cyberprobe` executes indefinitely - to end the program, a signal should be sent. e.g.

```
killall cyberprobe
```

6.2 cyberprobe configuration

The configuration file is re-read when it changes, and changes are immediately actioned.

Sample configuration:

```
<?xml version="1.0" encoding="ISO-8859-1"?>

<configuration>

  <!-- Start a control interface on port 8888. -->
  <control port="8888" username="admin" password="horse_battery_staple">

  <!-- Set of interfaces to use for collection. -->
  <interfaces>

    <!-- filter element is optional.  Can be used to make sure you don't
         sniff the outbound streams. -->
    <interface name="eth0" filter="not port 10001 and not port 10002"/>

    <-- The delay attribute can be used to specify a delay before
           packets are processed.  In seconds. -->
    <interface name="eth1" delay="0.5"/>

  </interfaces>

  <!-- Statically targeted addresses. -->
  <targets>
    <target address="192.168.1.1" liid="123456"/>
    <target address="192.168.1.2" liid="123981"/>
    <target address="10.2.0.0/16" liid="9123780"/>
    <target address="10.1.1.1" liid="9123780"/>
    <target address="10.1.1.1" liid="9123780"/>
```

```
  <target address="10.1.1.0" liid="591875"/>
  <target address="10.1.1.2" liid="492895"/>
  <target address="10.1.1.3" liid="591875"/>
  <target address="10.1.1.4" liid="591875"/>
  <target address="10.1.1.5" liid="591875"/>
  <target address="10.1.1.6" liid="591875"/>
  <target address="10.1.1.7" liid="591875"/>
  <target address="10.1.1.8" liid="591875"/>
  <target address="10.1.1.9" liid="591875"/>
  <target address="10.1.1.10" liid="591875"/>
  <target address="aaaa:bbbb:cccc:dddd::4:5:6"
    class="ipv6" liid="983898"/>
  <target address="aaaa:bbbb:cccc::/48"
    class="ipv6" liid="983800"/>
</targets>

<!-- Endpoints for delivery of collected packets. -->
<endpoints>

  <!-- Send collected packets to monitor1:10001 in NHIS 1.1
       stream. -->
  <endpoint hostname="monitor1" port="10001"
            transport="tcp" type="nhis1.1"/>

  <!-- Send collected packets to monitor2:10002 in ETSI LI
       stream. -->
  <endpoint hostname="monitor2" port="10002"
            transport="tcp" type="etsi"/>

</endpoints>

<!-- Set of parameters, primarily used to configure the metadata in
     ETSI LI metadata. -->
<parameters>

  <!-- Value used for deliveryCountryCode and authorizationCountryCode
       in LI PS PDU. Should be 2-character string. -->
  <parameter key="country" value="DE"/>

  <!-- Value used for operatorIdentifier in LI PS PDU. A string up to
       16 characters. -->
  <parameter key="operator" value="Cyber"/>

  <!-- Value used for networkElementIdentifier in LI PS PDU. String up
       to 16 characters in length. -->
  <parameter key="network_element" value="10.8.2.4"/>
```

```
        <!-- Value used for interceptionPointID in LI PS PDU. String up
             to 8 characters in length. -->
        <parameter key="interception_point" value="abcd1234"/>

        <!-- Username values used in IPIRI connection.  Key form is
             "username." plus the LIID -->
        <parameter key="username.123456" value="user01@example.org"/>
        <parameter key="username.123981" value="user02@example.org"/>
        <parameter key="username.981235" value="user03@example.org"/>

        <!-- Parameters in this form are used select the LIID which is used
             when packets are collected on Snort alerts.  Basically, this
             maps the Snort signature ID to a LIID. -->
        <parameter key="snort.1.liid" value="SNORT1"/>
        <parameter key="snort.2.liid" value="SNORT2"/>

       </parameters>

       <!-- Optional element.  Listens for Snort alerts, and dynamically
            targets addresses for 60 seconds. -->
       <!--
       <snort_alert socket="/var/log/snort/snort_alert" duration="60"/>
       -->

    </configuration>
```

The `control` element is optional, if it exists, `cyberprobe` runs a management interface on the specified port. The `port`, `username` and `password` attributes must be specified. See Section 3.3 [Management interface], page 12 for how to communicate with that interface.

The `interfaces` block defines a set of interfaces to sniff. The `name` attribute is mandatory, the `filter` element is optional, and if specified should describe a BPF (Berkley Packet Filter) expression. The `delay` element can be used to specify, in seconds, the duration to wait before packets are processed. The delay is specified as a floating point decimal.

The `targets` block defines IP address to match. The `address` attribute defines the IP address with optional mask used for the address match. If a mask is specified, this describes the subset of the address which will be used for matching. For instance, if `192.168.0.0/16` is specified, then a 16-bit mask will be applied, which makes this a class-B address match. That is, any address in the `192.168.0.0-192.168.255.255` range will match. If no mask is specified, then this is an exact match against a single address. The `liid` attribute defines the LIID which will be applied if this particular IP address is detected. The address must be an IP address, and not a hostname. The address can be an IPv6 address if the `class` attribute is included, and set to `ipv6`.

LIIDs can occur in multiple places in the target block, but an IP address should only occur once in the target block.

The `endpoints` block defines a set of addresses for delivery. The `hostname` and `port` attributes should be used to describe the endpoint address. Type `type` attribute should be `nhis1.1` or `etsi` to specify which output stream format to use. The `transport` describe the transport type, which should be `tcp` for standard TCP stream, or `tls` for an SSL/TLS stream. If TLS is invoked, the attributes `certificate`, `key` and `trusted-ca` should be specified, with filenames for client certificate, private key, and a trust CA chain. These should all be in PEM format.

The optional `parameters` block defines a set of parameters which are only used in ETSI delivery. Each parameter element should have a `key` and a `value` attribute. The parameter values for `country`, `operator`, `network_element` and `interception_point` describe values which are used in the `PSHeader` and `IRI` constructs. The parameters with prefix `username.` describe values for the `username` values in the IPIRI construct in ETSI LI. The `key` value is the literal `username.` suffixed with the LIID. If such an entry is present, it is used for the `username`. All parameters are optional, meaningless defaults (e.g. unknown) will be used if not specified.

6.3 `cyberprobe-cli` invocation

`cyberprobe-cli` connects to `cyberprobe` on the management port to allow dynamic administration. This permits dynamic management of resources.

> **Note:** You can end up in a confusing situation if you use both the configuration file, and the management interface to configure resources. It is best to use one or the other. You can safely use the configuration file for resources that you don't intend to change through the management interface, but you shouldn't use both the configuration file and management interface to change the same resources.

Synopsis:

```
cyberprobe-cli HOST PORT
```

Example:

```
cyberprobe-cli vpn-host031 8888
```

'`HOST`' Specifies the hostname or IP address of the host to connect to.

'`PORT`' Specifies the management port number.

Upon connection, you are prompted to enter a username and password. Upon successful authentication, you are then offered a command line prompt for administration commands.

6.4 `cyberprobe-cli` commands

The following commands are supported by `cyberprobe-cli`:

'`add endpoint HOST PORT TYPE TRANSPORT`'
: Adds a delivery endpoint.

  '`HOST`' Specifies the delivery host.

  '`PORT`' Specifies TCP port to deliver to.

  '`TYPE`' Can be one of '`nhis`' or '`etsi`' for delivery protocol.

  '`TRANSPORT`'
  : Can be one of '`tcp`' or '`tls`' for TCP or TLS transports.

Note: It is not possible to specify the appropriate transport paramters for TLS delivery using the management interface currently. (FIXME).

'`add interface INTERFACE DELAY [FILTER]`'
: Adds an interface for packet sniffing.

  '`INTERFACE`'
  : Interface name.

  '`DELAY`' Delay between packet acquisiton and delivery. Defaults to zero.

  '`FILTER`' Optional, species a filter to be applied for positive selection of packets, in BPF / libpcap format.

'`add parameter KEY VALUE`'
: Adds a parameter.

  '`KEY`' Parameter key.

  '`VALUE`' Parameter value.

'`add target LIID PROTOCOL ADDRESS`'
: Adds an address target for packet capture.

  '`LIID`' LIID / device identifier.

  '`PROTOCOL`'
  : Address protocol, one of '`ip4`' or '`ip6`'.

  '`ADDRESS`' Address value, in IPv4 or IPv6 format, according to the PROTOCOL value.

'`help`' Displays help (not implemented).

'`quit`' Causes the client to close the connection and terminate.

'`remove endpoint HOST PORT TYPE TRANSPORT`'
: Removes an endpoint added through the '`add endpoint`' command. The HOST, PORT TYPE and TRANSPORT values are the same as for '`add endpoint`'.

'`remove interface INTERFACE DELAY [FILTER]`'
: Removes an interface added through the '`add interface`' command. The INTERFACE, DELAY and FILTER values are the same as for '`add interface`'.

'`remove paramter KEY VALUE`'
: Removes a paramter added through the '`add parameter`' command. The KEY and VALUE values are the same as for '`remove parameter`'.

'`remove target PROTOCOL ADDRESS`'
: Removes a target added through the '`remove target`' command. The PROTOCOL and ADDRESS values are the same as for '`add target`'.

'`show endpoints`'
: Displays a table showing endpoints.

'`show interfaces`'
: Displays a table showing interfaces.

'`show parameters`'
: Displays a table showing parameters.

'`show targets`'
: Displays a table showing targets.

6.5 Output streaming protocols

`cyberprobe` supports packet output in one of two output formats, which are both LI formats. LI formats were chosen as they set good, open standards for streaming packets to a destination. There are also existing security products such as firewalls, and analysis tools which understand with these protocols. The two formats are ETSI LI and NHIS 1.1.

ETSI LI

The first of the formats supported is the ETSI LI format (see ETSI TS 102 232), which is used in Europe and internationally. The protocol is described using an ASN.1 specification which can be downloaded from the ETSI web-site. Google can find the standards. The overarching TS 102 232-1 standard describes the transport, while the TS 102 232-3 standard describes putting the IP packets in the transport.

Those adverse to the use of ASN.1 technology may prefer the second format.

NHIS LI

NHIS 1.1 which was defined for use in the UK in the 90s, based on GLIC in ETSI TS 101 671. The protocol is a much simpler header protocol than ETSI LI, and needs less work to decode.

The standard was available on the internet on the http://gliif.org website, but that web-site has recently gone offline.

The bluffers guide to decoding goes...

- The first 32 bytes after TCP connection are a header. Ignore the first 4 bytes, the latter 28 bytes are the LIID, represented as an ASCII string. Unused bytes following the LIID are set to zero to pad out to 32 bytes.
- Once the start header is sent, the following data consists of IP packets pre-fixed by a 20 byte header. The only information of note in each 20 byte header is a 2-byte length field at offset 2 (network byte order). This tells you the length of the IP packet.
- The IP packets are transmitted until the TCP connection closes. A separate TCP connection is used for each LIID.

Output semantics

`cyberprobe` automatically reconnects to failed destinations, but the buffering strategy is very simple. When destinations fail, the packets are buffered in a small queue, but there is limited buffering, so once the queue fills, packets will start to be dropped. The locking strategy is simple, so loss of a single endpoint will currently result in data loss to all endpoints. This may be a problem for operational scenarios where high data availability is required.

`cyberprobe` includes some code to decode the ETSI and NHIS streams, and also includes two test utilities, `etsi-rcvr` and `nhis11-rcvr` which listen on a specified port number, decode the stream data, and forward in PCAP format on standard output. Example usage would be:

```
etsi-rcvr 10001 | tcpdump -n -r-
nhis11-rcvr 10000 | tcpdump -n -r-
```

6.6 Management protocol

Overview

The management interface is a simple interface which supports studying and dynamically changing the cyberprobe configuration: endpoints, targets and interfaces.

The configuration file specifies a port number, and username and password for the interface.

The interface is intended to be used programmatically, but it is usable using a basic telnet. It is a command-response interface, similar in style to SMTP.

Commands

Commands are sent, one at a time, as a string terminated by a newline. The following commands are supported:

`auth <user> <password>`
: Used on initial connection to authenticate.

`help`
: Shows help

`add_interface <iface> <delay> [<filter>]`
: Starts packet capture from an interface.

`remove_interface <iface> <delay> [<filter>]`
: Removes a previously enabled packet capture.

`interfaces`
: Lists all interfaces, output is format `iface:delay:filter`.

`add_endpoint <host> <port> <type> <transport>`
: Adds an endpoint to delivery data to. where type is one of: `etsi nhis1.1` and transport is one of: `tcp tls`. Note that it is not currently possible to specify the configuration required to get a TLS connection to work. (FIXME).

`remove_endpoint <host> <port> <type> <transport>`
: Removes a previously enabled endpoint. where type is one of: `etsi nhis1.1` and transport is one of: `tcp tls`.

`endpoints`
: Lists endpoints, format is `host:port:type:description`.

`add_target <liid> <class> <address>`
`add_target <liid> <class> <address>/<mask>`
: Adds a new targeted IP address. where class is one of: `ipv4 ipv6`

`remove_target <liid> <class> <address>`
`remove_target <liid> <class> <address>/<mask>`
: Removes a previously targeted IP address. where class is one of: `ipv4 ipv6`

`targets`
: Lists targets, format is `liid:class:address/mask`. The mask value is always present, even when no mask was present when the target was added.

`add_parameter <key> <val>`
: Adds a new parameter, or changes a parameter value.

`remove_target <key>`
: Removes a parameter value.

`parameters`
: Lists parameters, format is `key:value`.

In response to a command, one of the following responses may occur:

- An OK response, which is a 200 status code and message. e.g. `200 Endpoint added.`
- An error message, which is also a status code and message. e.g. `301 Command not known.`

Error codes always start with 3 or 5. A 3xx error code results from something which is your fault e.g. procedural or syntactic violation, 5xx error codes result from errors internal to the system. This is still probably your fault :) e.g. specifying an interface which doesn't exist.

A response with a body, which is a 201 status code and message. This is followed by a single line containing a response size in bytes, followed by the response itself. e.g.

```
201 Interfaces list follows.
8
eth0:1:
```

Example session

For clarity, commands sent to the server are highlighted with '`>>`' although this is not present as a prompt or in the protocol dialogue.

```
>>  interfaces
    330 Authenticate before continuing.
>>  auth user password
    200 Authenticated.
>>  interfaces
    201 Interfaces list follows.
    8
    p4p1:1:
>>  remove_interface p4p1 1
    200 Removed interface.
>>  add_interface p4p1 8
    200 Added interface.
>>  add_target 123456 ipv4 1.2.3.4
    200 Added target.
```

```
>>  targets
    201 Targets list follows.
    65
    123456:ipv4:1.2.3.4/32
    123456:ipv4:192.168.1.80/32
    123456:ipv6:aaaa:bbbb:cccc:dddd::4:5:6/128
>>  quit
    200 Tra, then.
```

6.7 `cybermon` invocation

`cybermon` is a configurable network packet stream analyser. It is designed to receive packets from cyberprobe, analyse them and generate session/transport level events which result in user-configurable actions. For each event, a call is made to a Lua script which the caller provides. Synposes:

```
cybermon [--help] [--transport TRANSPORT] [--port PORT] [--key KEY]
        [--certificate CERT] [--trusted-ca CHAIN] [--pcap PCAP_FILE]
        [--config CONFIG]
```

- *TRANSPORT* is either '`tcp`' or '`tls`'. If '`tls`' is specified, '`cybermon`' expects to read data over TLS. In TLS mode, it is necessary to specify the key, certificate, and trusted CA files.
- *PORT* is a TCP port number. This form of the command runs as a TCP server listening for ETSI LI streams. See [ETSI LI], page 33.
- *KEY* specifies a filename for the private key in PEM format. Only used in TLS mode.
- *CERT* specifies a filename for the public certificate in PEM format. Only used in TLS mode.
- *CHAIN* specifies a filename for trusted CA keys in PEM format. Only used in TLS mode.
- *PCAP_FILE* is a PCAP file to read. This form of the command reads the PCAP file, and then exits. If the file is '`-`', standard input is read.
- *CONFIG* is a Lua configuration file, which specifies the action `cybermon` should take when certain events are observed. See Section 6.8 [`cybermon` configuration], page 36.

6.8 `cybermon` configuration

Overview

Cybermon is a simple monitoring tool. It receives the ETSI protocol, decodes the protocols, and makes decoded information available for further handling which you can specify. The tool is very much a work in progress - it has limited protocol decode capability at the moment, but there's enough there to demonstrate the idea. Usage

Usage is: `cybermon <port-number> <config-file>`

You specify a port number to receive data on, and a configuration file written in Lua. Lua is a simple but powerful scripting language. Here's an example to help you see how the configuration is used.

Example configuration

The configuration file is there to provide functions which get called when certain events occur. The calling interface is fairly simple at the moment, and over time, expect to see a richer interface develop.

To start with, we create the structure of the configuration file. Call it something with a `.lua` extension e.g. `config.lua` so that your editor knows how to indent the code. The basic structure is a module with a number of functions:

```
local observer = {}

-- This function is called when a trigger events starts collection of an
-- attacker. liid=the trigger ID, addr=trigger address
observer.trigger_up = function(liid, addr)
end

-- This function is called when an attacker goes off the air
observer.trigger_down = function(liid)
end

-- This function is called when a stream-orientated connection is made
-- (e.g. TCP)
observer.connection_up = function(context)
end

-- This function is called when a stream-orientated connection is closed
observer.connection_down = function(context)
end

-- This function is called when a datagram is observed, but the protocol
-- is not recognised.
observer.unrecognised_datagram = function(context, data)
end

-- This function is called when stream data  is observed, but the
-- protocol is not recognised.
observer.unrecognised_stream = function(context, data)
end

-- This function is called when an ICMP message is observed.
observer.icmp = function(context, data)
end

-- This function is called when an HTTP request is observed.
observer.http_request = function(context, method, url, header, body)
end

-- This function is called when an HTTP response is observed.
```

```
observer.http_response = function(context, code, status, header, url,
                         body)
end

-- This function is called when a DNS message is observed.
observer.dns_message = function(context, header, queries, answers, auth,
                                add)
end

-- Return the table
return observer
```

LUA event calls

The configuration file is expected to provide the following functions, which are called in response to `cybermon` events.

`trigger_up(liid, address)`
: Called when an attacker is seen coming on-stream. The `liid` parameter describes the target ID, and `address` contains the IP address in string form.

`trigger_down(liid)`
: Called when an attacker is seen going off-stream. The `liid` parameter describes the target ID.

`connection_up(context)`
: Called when a stream-based connection (e.g. TCP) is made. The `context` parameter is a LUA userdata variable which can't be access directly, but can be used with the functions described below to access further information from `cybermon`.

`connection_down(context)`
: Similar to `connection_up`, called when a connection closes.

`icmp(context, data)`
: Called when an ICMP message is detected. The `data` parameter contains the ICMP message body.

`http_request(context, method, url, header, body)`
: Called when an HTTP request is observed. The HTTP method and URL are described in the `method` and `url` parameters. The `header` parameter is a LUA table, which describes the HTTP header key/value pairs. If there is an HTTP payload in the request, it is contained in the `body` parameter, which is a string. Otherwise body will be an empty string.

`http_response(context, code, status, header, url, body)`
: Called when an HTTP response is observed. The HTTP response code and status are described in the `code` and `status` parameters. The `header` parameter is a LUA table, which describes the HTTP header key/value pairs. If there is an HTTP payload in the response, it is contained in the `body` parameter, which is a string. Otherwise body will be an empty string.

`smtp_command(context, command)`
: Called when an SMTP command is observed i.e. a single line message going to the server from a client. The `command` parameter contains the command string.

`smtp_response(context, status, text)`
: Called when an SMTP response is observed. That is, status going from server to client following a command. The `status` parameter is the status number e.g. 200. The `text` parameter contains the response text, described as a list of strings. Responses may occur over a number of lines, hence the parameter is a list: For single-line responses, there is only a single item in the list.

`smtp_data(context, from, to, data)`
: Called when an SMTP payload is observed i.e. the body of text following the DATA command. To aid processing, the SMTP protocol processor assembles information from other commands: the `from` parameter contains the email From address described in the MAIL FROM command. The `to` parameter is a list of addresses contained in all RCPT TO commands. The `data` parameter contains the email body - it will be an RFC822 payload.

`ftp_command(context, command)`
: Called when an FTP command is observed i.e. a single line message going to the server from a client. The `command` parameter contains the command string.

`ftp_response(context, status, text)`
: Called when an FTP response is observed. That is, status going from server to client following a command. The `status` parameter is the status number e.g. 200. The `text` parameter contains the response text, described as a list of strings. Responses may occur over a number of lines, hence the parameter is a list: For single-line responses, there is only a single item in the list.

`dns_message(context, header, queries, answers, auth, add)`
: Called when a DNS message is observed. The decoded DNS message is described in the parameters: `header` is the DNS header, `queries` contains the DNS queries, `answers` contains the answers in a response message, `auth` contains DNS nameserver authority descriptions, and `add` provides additional information.

`ntp_timestamp_message(context, hdr, info)`
: Called when a NTP timestamp message is observed. The decoded NTP message is described in the parameters: `hdr` is the ntp header, `info` contains the specific timestamp information.

`ntp_control_message(context, hdr, info)`
: Called when a NTP control message is observed. The decoded NTP message is described in the parameters: `hdr` is the ntp header, `info` contains the specific control information.

`ntp_private_message(context, hdr, info)`
: Called when a NTP control message is observed. The decoded NTP message is described in the parameters: `hdr` is the ntp header, `info` contains the specific private information.

`unrecognised_datagram(context, data)`
: Called when a datagram is received using a protocol which isn't recognised. Currently, only DNS, ICMP and NTP are recognised. Any other UDP protocol results in a call to this function.

`unrecognised_stream(context, data)`
: Called when connection-orientated data is received using a protocol which isn't recognised. Currently, only HTTP, SMTP and FTP are recognised. Any other TCP protocol results in calls to this function whenever data is observed.

Context object

From the LUA code there, the `context` variable has a number of method functions which can be called:

`context:get_type()`
: Returns the protocol type of the context e.g. `http`, `tcp`, `udp`, `dns`, `ip4`

`context:get_parent()`
: Returns the parent context relating to a context. This can be used to travel "up" the protocol stack. For example, call get_parent on a TCP context will return the IP context.

`context:get_src_addr()`
: Returns the source address relating to a context. Returns two string variables: the first is the address class e.g. `ipv4`, the second is the address value e.g. `1.2.3.4`.

`context:get_dest_addr()`
: Returns the destination address relating to a context. Returns two string variables: the first is the address class e.g. `ipv4`, the second is the address value e.g. `1.2.3.4`.

`context:get_reverse()`
: Returns the context relating to the "other side" of a communication, but only if this has been identified. On an HTTP response, `get_reverse` will return the HTTP request. In the `http_request` function you will not be able to use `get_reverse` to find the HTTP response because the response does not exist at the point the request is identified.

`context:get_id()`
: Returns a context's unique ID. Can be useful for tracking, or can be used as index into your own LUA structures to associate information with contexts.

`context:describe_src()`
: Returns a human readable description of the protocol stack using source addresses.

`context:describe_dest()`
: Returns a human readable description of the protocol stack using source addresses.

`context:get_liid()`
: Returns the trigger ID associated with a "target".

`context:get_network_info()`
: Returns two variables: the source and destination network addresses (IP addresses) for this data. These are in normal IP address string format.

`context:get_trigger_info()`
: Returns the IP address which triggered this collection, if known. If not, `0.0.0.0x` is returned. This is in normal IP address string format.

`context:forge_tcp_reset()`
: Creates a TCP reset packet and directs it at the source address associated with this context. Must have TCP protocol present in the stack.

`context:forge_dns_response(header, queries, answers, add)`
: Creates a DNS message and directs it at the source address associated with this context. The provided parameters are used as protocol data in the DNS encoder.

6.9 `cybermon` example configurations

Example configuration files

`db.lua`
: Connects to a local ElasticSearch instance, and generates observations which are stored as `observation` objects in the `cyberprobe` index. A mapping is applied which applies a time-to-live of 1 hour on all objects.

`dump.lua`
: Outputs event payloads to `data/dump.*` files.

`forge-dns.lua`
: Example Lua script, spots DNS queries for '`example.org`', and responds with made-up IP addresses.

`forge-reset.lua`
: Example script, spots TCP port 22 sessions (which is the port number normally used for SSH sessions). If detected, a TCP reset is forged.

`hexdump.lua`
: Like `monitor.lua`, but adds a hex-dump of event payloads to the output.

`monitor.lua`
: For each Lua event, outputs a plain text summary of the output on standard output.

`zeromq.lua`
: For each Lua event, a JSON record is formatted and published to a ZeroMQ queue on port 5555. See Section 6.10 [Cybermon ZeroMQ message format], page 42.

`quiet.lua`
: Does nothing. This is an empty code shell, and a good template to write your own event handler.

`stix+alert.lua`
: Looks in the current directory for the JSON file `stix-default-combined.json` which is read for STIX indicators.

  Then, scans events for threats, and if detected are alerted on standard output in a human-readable form.

`stix+db.lua`
: Like `stix+alert.lua` but also generates ElasticSearch observations as `db.lua` does. The ElasticSearch observations have threat hit information added.q

`volmon+alert.lua`
: Like `volmon` but alerts are written to a TCP server on port 10101.

`volmon.lua`
: Monitors all sessions and calculates volumes of data. Creates a human-readable alert when volumes exceed a certain value.

Utilities

The `/usr/local/etc/cyberprobe/util` directory contains some Lua utilities which can be used by other Lua configuration files. They can be loaded as modules e.g.

```
local addr = require("util.addresses")
```

The utilities are:

`addresses.lua`
: Some `cybermon` address handling functions.

`elastic.lua`
: ElasticSearch observation creation.

`http.lua`
: HTTP transport functions.

`stix.lua`
: Utilities used to read STIX threat specifications, and detect their presence in `cybermon` events.

6.10 Cybermon ZeroMQ message format

Cybermon's '`zeromq.lua`' configuration file transmits messages to a ZeroMQ message queue in JSON format. Each message is a JSON object with the following fields:

'`id`'
: Unique ID for the event: UUID format (e.g. 3c55d830-8d99-48a1-c8cd-ca77514a6d10).

'`device`'
: Device identifier / LIID.

'`action`'
: The event type. One of:

  '`connected_up`'
  : Records the creation of a stream-orientated connection (currently, only TCP). This event is created for all connections whether the protocol is recognised or not.

‘connected_down’
: Records the closing of a stream-orientated connection (currently, only TCP). This event is created for all connections whether the protocol is recognised or not.

‘unrecognised_stream’
: Records the sending of a PDU on a connection-less transport (currently, only UDP) whose protocol has not been recognised.

‘unrecognised_datagram’
: Records the sending of a PDU on a connection-less transport (currently, only UDP) whose protocol has not been recognised.

‘http_request’
: Records the sending of an HTTP request.

‘http_response’
: Records the sending of an HTTP response.

‘dns_message’
: Records the sending of a DNS message (request and response).

‘icmp’
: Records the sending of an ICMP message.

‘smtp_command’
: Records the sending of an SMTP command. This is a message from client to server. Data commands are not recorded with this event - there is an ‘smtp_data’ event which records this.

‘smtp_response’
: Records the sending of a response to an SMTP command. This is a status message from server to client.

‘smtp_data’
: Records an SMTP data transaction, including the full SMTP data payload (essentially an email).

‘ftp_command’
: Records an FTP command (client to server).

‘ftp_response’
: Records an FTP response (server to client).

‘ntp_message’
: Records the sending of a NTP message, including the NTP hdr (mode, version, leap second indicator)

‘queries’
: Describes DNS query records in ‘dns_message’ actions. Is a list of objects with ‘name’, ‘type’ and ‘class’ fields containing strings for name, type and class

‘answers’
: Describes DNS answer records in ‘dns_message’ actions. Is a list of objects with ‘name’, ‘type’ and ‘class’ and ‘address’ fields containing strings for name, type and class and IP address.

‘type’
: DNS message type, one of ‘query’ or ‘response’.

'method' HTTP method

'url' HTTP URL.

'header' An object containing key/value pairs for HTTP header.

'code' A response code in HTTP response, SMTP response or FTP response.

'status' A human-readable status string in HTTP response, SMTP response or FTP response.

'command' Command string in FTP or SMTP protocols.

'text' Reply text in FTP or SMTP protocols.

6.11 cybermon-monitor invocation

cybermon-monitor subscribes to a ZeroMQ pub/sub queue for cybermon events, and upon receipt of events, formats them for output in a human-readable manner.

Synopsis:

```
cybermon-monitor [BINDING]
```

Example:

```
cybermon-monitor
cybermon-monitor tcp://localhost:5555
```

'BINDING' Specifies the ZeroMQ pub/sub queue to connect to. If not specified, defaults to 'tcp://localhost:5555'.

6.12 cybermon-elasticsearch invocation

cybermon-elasticsearch subscribes to a ZeroMQ pub/sub queue for cybermon events, and upon receipt of events, formats them for delivery to an ElasticSearch store.

Synopsis:

```
cybermon-elasticsearch [BINDING [ELASTICSEARCH-URL] ]
```

Example:

```
cybermon-elasticsearch
cybermon-elasticsearch tcp://localhost:5555 http://elastic-store:9200/
```

'BINDING' Specifies the ZeroMQ pub/sub queue to connect to. If not specified, defaults to 'tcp://localhost:5555'.

'ELASTICSEARCH-URL'
Specifies the base URL for ElasticSearch. If not specified, defaults to 'http://localhost:9200'.

6.13 cybermon-bigquery invocation

cybermon-bigquery subscribes to a ZeroMQ pub/sub queue for cybermon events, and upon receipt of events, formats them for delivery to a Google BigQuery table.

Synopsis:

```
cybermon-bigquery [BINDING [KEY-FILE [PROJECT [DATASET [TABLE] ] ] ] ]
```

Example:

```
cybermon-bigquery
cybermon-bigquery tcp://localhost:5555 /priv.json
```

'BINDING' Specifies the ZeroMQ pub/sub queue to connect to. If not specified, defaults to 'tcp://localhost:5555'.

'KEY-FILE'
Specifies the path to a Google cloud key file in 'private JSON' format. If not specified, defaults to /etc/cyberprobe/private.json.

'PROJECT' Specifies the Google Cloud project ID to use. Defaults to the project ID specified in the private JSON key file.

'DATASET' Specifies the BigQuery data set, defaults to 'cyberprobe'. You need to create this dataset, it is not created for you.

'TABLE' Specifies the BigQuery table within the dataset. This is created if it does not already exist. Don't try to create this yourself, if you use the wrong schema, data won't load correctly.

6.14 cybermon-gaffer invocation

cybermon-gaffer subscribes to a ZeroMQ pub/sub queue for cybermon events, and upon receipt of events, formats them for delivery to a Gaffer store. The format used is intended to allow Gaffer to be used as an RDF store with SPARQL query. To query and visualise the data stored in Gaffer, see https://github.com/cybermaggedon/gaffer-tools. To get started with Gaffer quickly, a docker container for development can be found at https://docker.io/cybermaggedon/gaffer.

Synopsis:

```
cybermon-gaffer [BINDING [GAFFER-URL] ]
```

Example:

```
cybermon-gaffer
cybermon-gaffer tcp://localhost:5555 \
    http://gaffer-store:8080/example-rest/v1
```

'BINDING' Specifies the ZeroMQ pub/sub queue to connect to. If not specified, defaults to 'tcp://localhost:5555'.

'GAFFER-URL'
Specifies the base URL for Gaffer. If not specified, defaults to 'http://gaffer:8080/example-rest/v1'.

The Gaffer subscriber is intended to work with a Gaffer schema which is installed at /usr/local/share/doc/cyberprobe/gaffer-schema.json.

6.15 cybermon-cassandra invocation

`cybermon-cassandra` subscribes to a ZeroMQ pub/sub queue for `cybermon` events, and upon receipt of events, formats them for delivery to a Cassandra store. The format used is intended to allow Cassandra to be used as an RDF store with SPARQL query. To query and visualise the data stored in Cassandra, see https://github.com/cybermaggedon/cassandra-redland.

Synopsis:

```
cybermon-cassandra [BINDING [CASSANDRA-HOSTS] ]
```

Example:

```
cybermon-cassandra
cybermon-cassandra tcp://localhost:5555 cassandra1,cassandra2
```

'`BINDING`' Specifies the ZeroMQ pub/sub queue to connect to. If not specified, defaults to '`tcp://localhost:5555`'.

'`CASSANDRA-HOSTS`'
Specifies a comma-separated list of Cassandra store hosts to contact. If not specified, defaults to '`localhost`'.

6.16 taxii-client invocation

`taxii-client` provides a means to connect with a TAXII compliant server to acquire cyber threat information. TAXII/STIX implementation is experimental and incomplete.

See https://taxii.mitre.org/ for more information on TAXII and STIX. Synopsis:

```
taxii-client [-h] [--host HOST] [--port PORT] [--path PATH]
        [--collection COLLECTION] [--begin_timestamp BEGIN_TS]
        [--end_timestamp END_TS] [--discovery] [--poll]
        [--collection_information] [--subscribe] [--action ACT]
        [--query QUERY] [--subs-id SUBSCRIPTION_ID]
        [--inbox INBOX]
```

Example:

```
taxii-client -h taxii.com --poll
```

'`-h`'
'`--help`' Shows command line usage.

'`--host` *HOST*'
Specifies host to connect to.

'`--port` *PORT*'
Specifies port number of the TAXII service.

'`--path` *PATH*'
Specifies the URI of the service. Default is '`/`'.

'`--collection` *COLLECTION*'
Specifies the TAXII collection to use. Default is '`default`'.

'`--begin_timestamp` *BEGIN*'
Specifies the TAXII collection to use. Default is '`default`'.

'--end_timestamp *END*'
: Specifies the TAXII collection to use. Default is 'default'.

'--discovery'
: Invokes a TAXII discovery action.

'--poll'
: Invokes a TAXII poll action.

'--collection_information'
: Invokes a collection information action.

'--subscribe'
: Invokes a TAXII subscribe action.

'--action *ACT*'
: Specieis the subscription action to perform.

'--query *QUERY*'
: Specifies the query to use for an inbox or poll action. Query takes the form: 'type:value'. Type can be one of:

  'address' CybOX address object value e.g. 'address:1.2.3.4'

  'addresstype'
  : CybOX address object type e.g. 'addresstype:e-mail'

  'domainname'
  : CybOX DNS name

  'port' TCP/UDP port number e.g. 'port:11111'

  'hash' File object hash value.

  'id' Object ID.

  'source' Object source identifier.

  Multiple query values may be specified in which case they are combined with a logical AND.

'--subs-id *SUBS-ID*'
: Specifies the subscription ID for a subscription operation.

'--inbox *INBOX*'
: Specifies the inbox destination for subscriptions. The default value is http://localhost:8888/.

Begin/end timestamps take the following form:

```
YYYY-MM-DDTHH:MM:SS.ssssss+/-hh:mm
```

6.17 taxii-sync-json invocation

taxii-sync-json provides a means to connect with a TAXII compliant server to acquire cyber threat information. taxii-sync-json uses a TAXII poll request, and reformats all STIX information into a single JSON file which is written to the current directory. This JSON form is intended to be used with the stix+db.lua and stix+alert.lua configuration files for cybermon. See Section 6.9 [cybermon example configurations], page 41.

TAXII/STIX implementation is experimental and incomplete.

See https://taxii.mitre.org/ for more information on TAXII and STIX. Synopsis:

```
taxii-sync-json [-h] [--host HOST] [--port PORT] [--path PATH]
         [--collection COLLECTION] [--begin_timestamp BEGIN_TS]
         [--end_timestamp END_TS]
```

Example:

```
taxii-sync-json -h taxii.com
```

'-h'
'--help' Shows command line usage.

'--host *HOST*'
Specifies host to connect to.

'--port *PORT*'
Specifies port number of the TAXII service.

'--path *PATH*'
Specifies the URI of the service. Default is '/'.

'--collection *COLLECTION*'
Specifies the TAXII collection to use. Default is 'default'.

'--begin_timestamp *BEGIN*'
Specifies the TAXII collection to use. Default is 'default'.

'--end_timestamp *END*'
Specifies the TAXII collection to use. Default is 'default'.

The JSON information is written to the current directory to a file called stix-*COLLECTION*-combined.json where *COLLECTION* is the collection name chosen.

Begin/end timestamps take the following form:

```
YYYY-MM-DDTHH:MM:SS.ssssss+/-hh:mm
```

6.18 taxii-server invocation

taxii-server provides a TAXII compliant server to distribute cyber threat information. TAXII/STIX implementation is experimental and incomplete.

See https://taxii.mitre.org/ for more information on TAXII and STIX. Synopsis:

```
taxii-server [-h] [--host HOST] [--port PORT] [--data-dir DATA_DIR]
         [--db DB] [--sync-period SYNC_PERIOD]
```

Example:

```
taxii-server --port 8100 --data-dir data/ --db stix.db
```

'-h'
'--help' Shows command line usage.

'--host *HOST*'
Host to bind the HTTP service to.

'--port *PORT*'
Specifies port number of the TAXII service.

'`--data-dir` *PATH*'
: Specifies the directory where STIX files are to be placed. Directory structure should be *PATH/COLLECTION/STIX-FILE*.

'`--db` *DB*'
: Specifies a file to hold the STIX data. Default is `stix_store.db`. This is created if it does not exist.

'`--sync-period` *PERIOD*'
: Specifies the period for synchronising the data directory with the database. Default is '`1`'.

The TAXII server periodically checks the data directory with the contents of the database, and updates the database accordingly. Deleting files results in deletion from the database, adding files results in creation. Thus, the data directory is the master copy for the sync process.

6.19 `nhis11-rcvr` invocation

`nhis11-rcvr` provides a TCP server which accepts connections from NHIS LI clients, decodes NHIS LI streams and outputs contained IP packets on the standard output in PCAP format. TCP port number to use is provided on the command line. Synopsis:

```
nhis11-rcvr port-number
```

- *port-number* is the TCP port number to list to for connections. See [NHIS LI], page 33.

`nhis11-rcvr` executes indefinitely - to end the program, a signal should be sent. e.g.

```
killall nhis11-rcvr
```

6.20 `etsi-rcvr` invocation

`etsi-rcvr` provides a TCP server which accepts connections from ETSI LI clients, decodes ETSI LI streams and outputs contained IP packets on the standard output in PCAP format. TCP port number to use is provided on the command line. Synopsis:

```
etsi-rcvr port-number
```

- *port-number* is the TCP port number to list to for connections. See [ETSI LI], page 33.

`etsi-rcvr` executes indefinitely - to end the program, a signal should be sent. e.g.

```
killall etsi-rcvr
```

6.21 ElasticSearch model

Overview

When `cybermon` is used with the `stix+db.lua` or `db.lua` configuration files, observations are created in an ElasticSearch database. These configuration files call the `elastic.lua` utility module. This section describes the data model used in the ElasticSearch database.

ElasticSearch accepts data in JSON form. `cybermon` uses an index called `cyberprobe` and an object type `observation`.

Here is an example of a JSON payload which is emitted for a DNS request:

```
{
  "observation": {
    "type": "query",
    "answers": {},
    "liid": "123456",
    "dest": {
      "udp": ["53"],
      "dns": [""],
      "ipv4": ["192.168.1.1"]
    },
    "queries": {
      "name": ["news.bbc.co.uk"],
      "type": ["1"],
      "class": ["1"]
    },
    "src": {
      "udp": ["57291"],
      "dns": [""],
      "ipv4": ["192.168.1.100"]
    },
    "time": "20141018T175059.366Z",
    "action": "dns_message",
    "oid": 1
  }
}
```


Common fields

The following fields are emitted for all observations:

`observation`
: This is a JSON object which describes a Cyberprobe observation.

`observation.oid`
: A unique object ID.

`observation.time`
: Describes the time of the event in GMT. The components are:

- 4-digit year
- 2-digit month
- 2-digit date
- Literal '`T`'.
- 2-digit hour (24-hour).
- 2-digit minute
- 2-digit second
- Literal '`.`'
- 3-digit milliseconds

- Literal 'Z'

e.g. 20141018T175059.366Z.

`observation.liid`
A string containing the targeted LIID.

`observation.action`
Describes the type of a Cyberprobe observation. See [Actions], page 51 below.

`observation.src`
An object describing the full stack of protocol destination addresses. For each name/value pair, the name is the protocol name, and the value is an array of strings which are protocol addresses. For example:

```
"src": {
  "udp": ["57291"],
  "dns": [""],
  "ipv4": ["192.168.1.100"]
}
```

This specifies a UDP source port number of 57291, and an IP source address of 192.168.1.100. Each protocol layer is list, allowing for more than one address - protocol tunnels may result in more than IP address, for instance.

`observation.dest`
An object describing the full stack of protocol destination addresses, like `observation.src` above, but for destination addresses.

Actions

The following `action` fields are defined:

'`connected_up`'
Records the creation of a stream-orientated connection (currently, only TCP). This event is created for all connections whether the protocol is recognised or not.

'`connected_down`'
Records the closing of a stream-orientated connection (currently, only TCP). This event is created for all connections whether the protocol is recognised or not.

'`unrecognised_stream`'
Records the sending of a PDU on a connection-less transport (currently, only UDP) whose protocol has not been recognised.

'`unrecognised_datagram`'
Records the sending of a PDU on a connection-less transport (currently, only UDP) whose protocol has not been recognised.

'`http_request`'
Records the sending of an HTTP request.

'`http_response`'
Records the sending of an HTTP response.

'dns_message'
: Records the sending of a DNS message (request and response).

'icmp'
: Records the sending of an ICMP message.

'smtp_command'
: Records the sending of an SMTP command. This is a message from client to server. Data commands are not recorded with this event - there is an 'smtp_data' event which records this.

'smtp_response'
: Records the sending of a response to an SMTP command. This is a status message from server to client.

'smtp_data'
: Records an SMTP data transaction, including the full SMTP data payload (essentially an email).

'ftp_command'
: Records an FTP command (client to server).

'ftp_response'
: Records an FTP response (server to client).

Connection up

Connection up events are created when connection-orientated transports (e.g. TCP) are created, and have an `action` field of '`connection_up`'.

Connection down

Connection down events are created when connection-orientated transports (e.g. TCP) are closed and have an `action` field of '`connection_down`'.

Unrecognised datagram

Unrecognised datagram events are created when a datagram is observed on an unrecognised protocol, and have an `action` field of '`unrecognised_datagram`'. Such events include the following fields:

`observation.data`
: The datagram payload, base64 encoded.

Unrecognised stream

Unrecognised stream events are created when data is observed to be sent on an unrecognised connection-orientated protocol (e.g. TCP), and have an `action` field of '`unrecognised_stream`'. Such events include the following fields:

`observation.data`
: The datagram payload, base64 encoded.

ICMP

ICMP events are created when an ICMP message is observed and have an `action` field of '`icmp`'. Such events include the following fields:

`observation.data`
: The datagram payload, base64 encoded.

DNS messages

DNS events are created for DNS query and response messages, and have an `action` field of '`dns_message`'. Such events include the following fields:

`observation.type`
: Used to describe the type of a DNS message, by interpreting the message flags. Will be '`query`' or '`response`'.

`observation.queries`
: Contains a list of DNS queries. Example:

```
"queries": [
 {
    "class: "1",
    "name": "news.bbc.co.uk",
    "type": "1"
 }
]
```

`observation.answers`
: Contains a list of DNS responses. Example:

```
"answers": [
  {
    "class: "1",
    "name": "newswww.bbc.net.uk",
    "type": "1"

  },
  {
    "class: "1",
    "address": "212.58.246.85",
    "name": "newswww.bbc.net.uk",
    "type": "1"
  },
  {
    "class: "1",
    "address": "212.58.246.84",
    "name": "newswww.bbc.net.uk",
    "type": "1"
  }
]
```

HTTP request

HTTP request events are created for HTTP requests, and have an `action` field of '`http_request`'. Such events include fields:

`observation.method`
: The HTTP method e.g. '`GET`', '`POST`'.

`observation.url`
: The HTTP URL e.g. '`http://www.bbc.co.uk/index.html`'.

`observation.header`
: An object containing the request headers e.g.

```
{
  "Accept": "*\/*",
  "Referer": "http:\/\/www.bbc.co.uk\/news\/",
  "Accept-Language": "en-gb,en;q=0.5",
  "Host": "www.bbc.co.uk",
  "Accept-Encoding": "gzip, deflate",
  "Connection": "keep-alive",
  "User-Agent": "Test/5.0"
}
```

`observation.body`
: Describes the HTTP body. This is a base64 encoding of the body.

HTTP response

HTTP response events are created for responses to HTTP requests, and have an `action` field of '`http_response`'. Such events include the following fields:

`observation.code`
: The HTTP status code e.g. '`200`'.

`observation.status`
: The HTTP status response e.g. '`OK`'.

`observation.url`
: The HTTP URL e.g. '`http://www.bbc.co.uk/index.html`'. This is obtained by studying the HTTP request, so will only be present where the HTTP request is observed.

`observation.header`
: An object containing the response headers e.g.

```
{
  "Server": "Apache",
  "Content-Type": "text/javascript"
}
```

`observation.body`
: Describes the HTTP response body, base64 encoded.

SMTP command

SMTP commands events are created when an SMTP command is sent from client to server, and have an `action` field of '`smtp_command`'. Such events include the following fields:

`observation.command`
: The SMTP command e.g. '`EHLO`'.

SMTP response

SMTP response events are created when an SMTP response is sent from server to client, and have an `action` field of '`smtp_response`'. Such events include the following fields:

`observation.status`
: The SMTP status e.g. '`400`'.

`observation.text`
: The SMTP text e.g. '`["Hello malware.com. Pleased to meet you."]`'.

SMTP data

SMTP data events are created when an SMTP email is sent from client to server, and have an `action` field of '`smtp_data`'. Such events include the following fields:

`observation.from`
: The SMTP "from" address. A string.

`observation.to`
: The SMTP "to" addresses. An array of strings.

`observation.data`
: The SMTP payload (RFC822), base64 encoded.

FTP command

FTP commands events are created when an FTP command is sent from client to server, and have an `action` field of '`ftp_command`'. Such events include the following fields:

`observation.command`
: The FTP command.

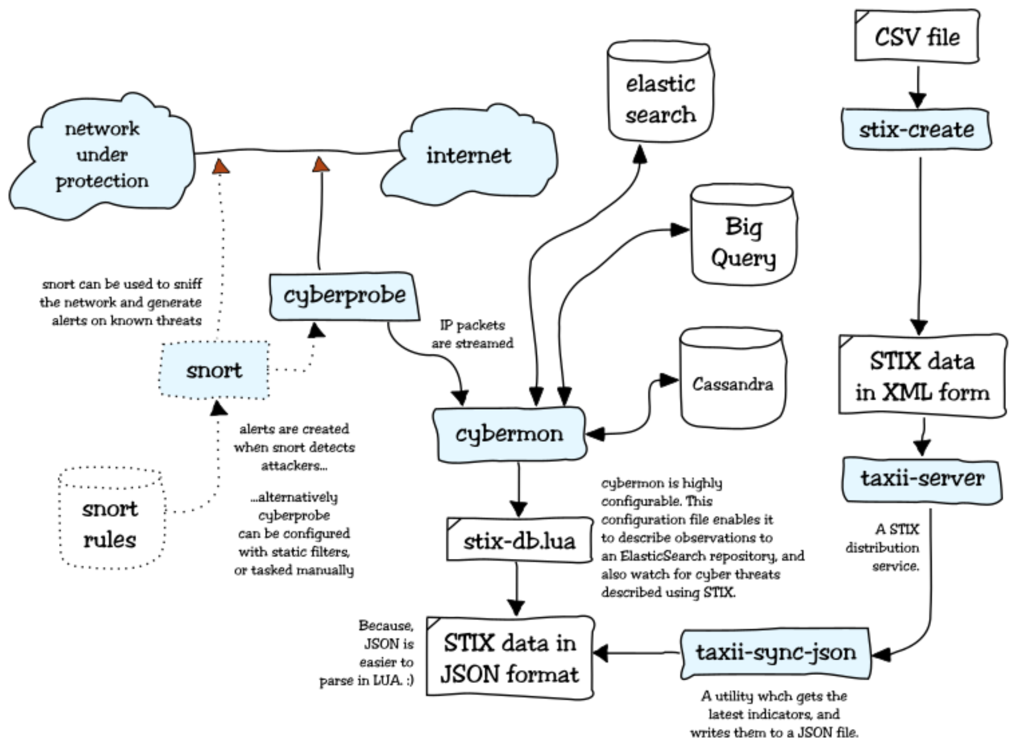
FTP response

FTP response events are created when an FTP response is sent from server to client, and have an `action` field of '`ftp_response`'. Such events include the following fields:

`observation.status`
: The FTP status.

`observation.text`
: The FTP text.

7 Architecture



Cyberprobe consists of a set of loosely-coupled components which can be used together. We prefer to use simple interfaces, and prefer to use interfaces which are standards. Here's how we envisage these components being used:

`cyberprobe`
: is a network sniffer which collects packets which match an IP address list. The packets collected are streamed using network streaming protocols. The IP address match list can be statically configured (in a configuration file), can be dynamically changed using a management interface, or can be dynamically changed as a result of Snort alerts.

`cybermon`
: receives packets from cyberprobe, analyses them and generates session/transport level events which result in user-configurable actions. For each event, a call is made to a Lua script which the caller provides.

`stix+db.lua`
: is a cybermon configuration file we provide. It translates the cybermon events into a JSON description which is fed into an ElasticSearch database. This configuration file also reads a STIX configuration file for cyber threat indicators. When these indicators are observed, the indicator meta-data is also added to the JSON events.

`zeromq.lua`
: is a cybermon configuration file we provide which publishes data to a ZeroMQ pub/sub queue. It allows connection of consumers to the `cybermon` event stream.

`cybermon-bigquery`
: is a ZeroMQ subscriber which output `cybermon` events to a Google BigQuery table.

`cybermon-cassandra`
: is a ZeroMQ subscriber which output `cybermon` events to a Cassandra store.

`cybermon-elasticsearch`
: is a ZeroMQ subscriber which output `cybermon` events to a ElasticSearch store.

`cybermon-gaffer`
: is a ZeroMQ subscriber which output `cybermon` events to a Gaffer store.

`taxii-server`
: is a TAXII compliant server, which is used to distribute STIX rules over HTTP.

`taxii-client-json`
: is a TAXII compliant client, which fetches STIX data over TAXII and write it to a JSON file in a way that `stix+db.lua` can read.

`snort`
: is not part of cyberprobe, but it's a great NIDS, so we use that.

Appendix A Adding a map to the dashboard

> **Note:** FIXME: This bit of the documentation is out of date with respect to the main documentation.

Wouldn't it be good if our visual dashboard had a world map that showed the source of packets? This last bit involves some experimental software.

First step is to get hold of a database which maps IP addresses to countries. There are several, but the GeoIP database is widely available and free. Check out the licence for yourself, though. The packages for your distribution are probably called GeoIP-devel and GeoIP. Debian has libgeoip-dev. So, install those with your favourite package manager. On Redhat/Fedora:

```
sudo yum install GeoIP-devel and GeoIP
```

or Debian/Ubuntu:

```
sudo apt-get install geoip-database # GeoLite Country only
sudo apt-get install libgeoip-dev
```

Next step is to download the database:

```
geoipupdate
```

Next, we need Lua support for GeoIP. First, download:

```
mkdir lua-geoip
cd lua-geoip
wget \
http://files.luaforge.net/releases/geoip/geoip/0.1-1/\
geoip-0.1-1.tar.gz
tar xvfz geoip-0.1-1.tar.gz
cd geoip-0.1-1
```

On my distribution, the code doesn't compile, so need to apply a patch which I have stashed in the cyberprobe source code.

```
# Check patch applies without error.
patch -p1 --dry-run  < ../../lua-geoip.patch
# Apply patch for real.
patch -p1  < ../../geoip.patch
```

Finally, the Makefile supplied doesn't work, so compile by hand:

```
gcc -fPIC -c geoip.c -o geoip.o
gcc -shared geoip.o -o geoip.so -lGeoIP
```

At this point, you should have a file `geoip.so`. You should test whether it loads in Lua. You type the bits after the '`>`' prompt:

```
$ lua
Lua 5.2.2  Copyright (C) 1994-2013 Lua.org, PUC-Rio
> =require("geoip")
table: 0xf55bb0
> =require("geoip").open_type
function: 0x7f738c9db24f
```

As long as you see a table and a function returned in Lua, this is good to go. Next step, is to copy that geoip.so file to the place where you were running `cybermon`. It has to be in your current directory. Then, restart Cybermon, it should be loaded by the `stix+db.lua` configuration file.

Finally, on Kibana, load a new dashboard, instead of loading `kibana-dashboard.json`, load `kibana-dashboard-map.json`, and you'll see a map. When sources of data are located to a particular location, it will start to colour as the counts increase.

As I say, we're reliant on some Lua software which doesn't seem to be actively maintained, so you may have problems here.

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Version 1.3, 3 November 2008

0. PREAMBLE

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