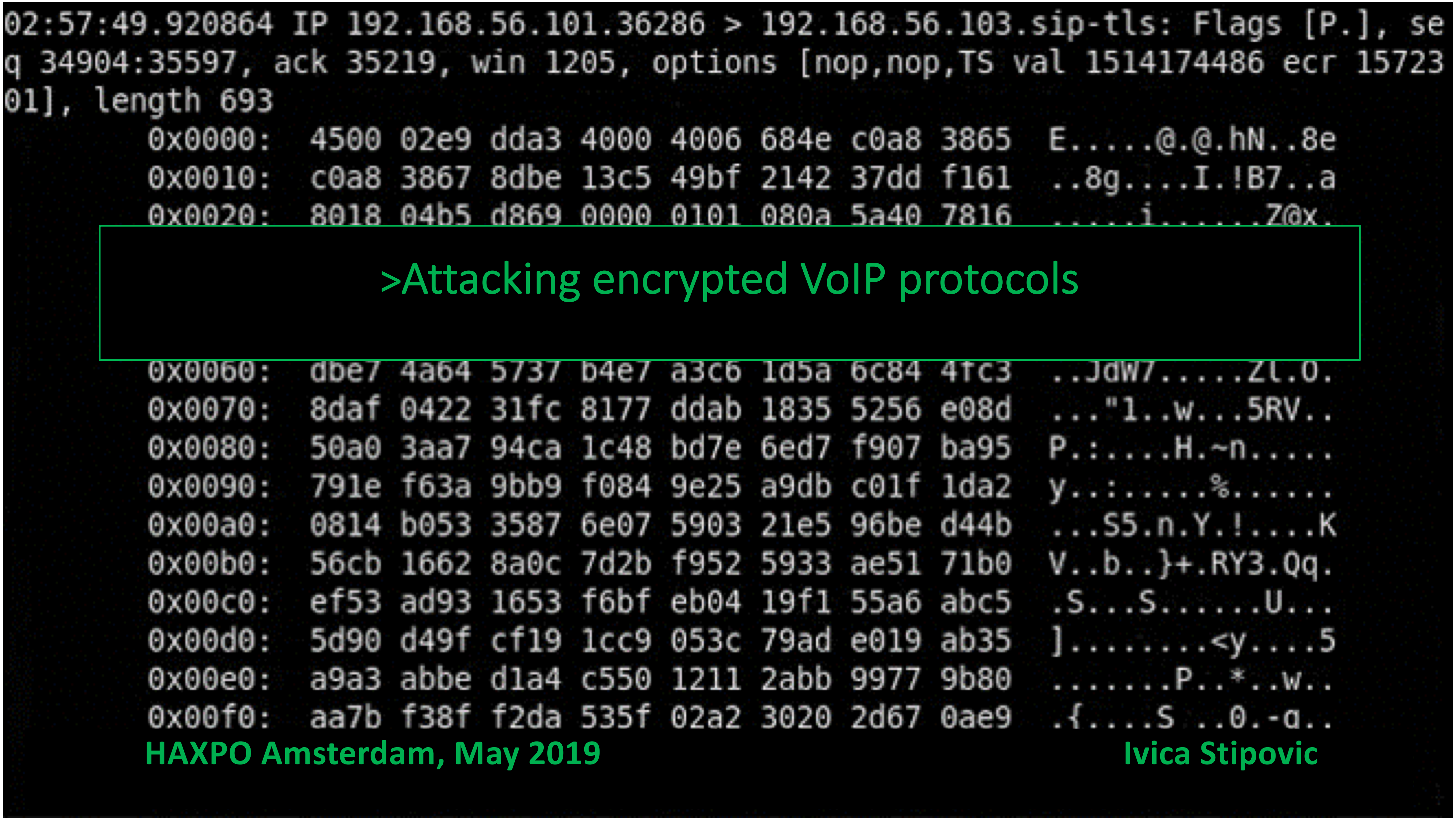


>Attacking encrypted VoIP protocols

HAXPO Amsterdam, May 2019

Ivica Stipovic

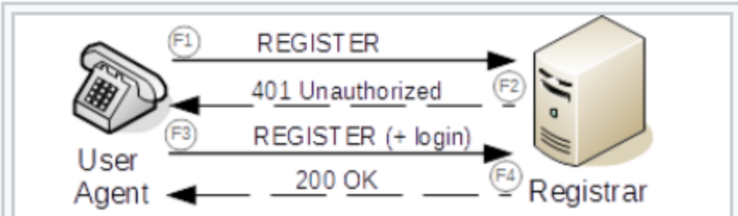
Biography

1. Name>Ivica [Eeveetsa] Stipovic
2. Work>Ward Solutions, Dublin, Ireland
3. Job>Information Security Consultant
4. Contact> Ivica.Stipovic@ward.ie
5. >EOF

What is VoIP protocol ?

- VOIP stands for (Voice Over IP) - Voice /Video/messaging that uses IP-based transport protocols for transmission
- What is SIP?

  SIP stands for Session Initiation Protocol (it is a voice control protocol), developed by IETF
- SIP is one of the predominant VOIP control protocols



SIP user agent registration to SIP registrar with authentication.

Source: https://en.wikipedia.org/wiki/Session_Initiation_Protocol

SIP,MGCP,H.323,XMPP…

There are other VoIP protocols as well

- MGCP Media Gateway Control Protocol (MGCP), connection management for media gateways
- H.323 - one of the first VoIP call signaling and control protocols that found widespread implementation
- XMPP - Extensible Messaging and Presence Protocol , instant messaging, presence information, and contact list maintenance
- Skype protocol, proprietary Internet telephony protocol suite based on peer-to-peer architecture

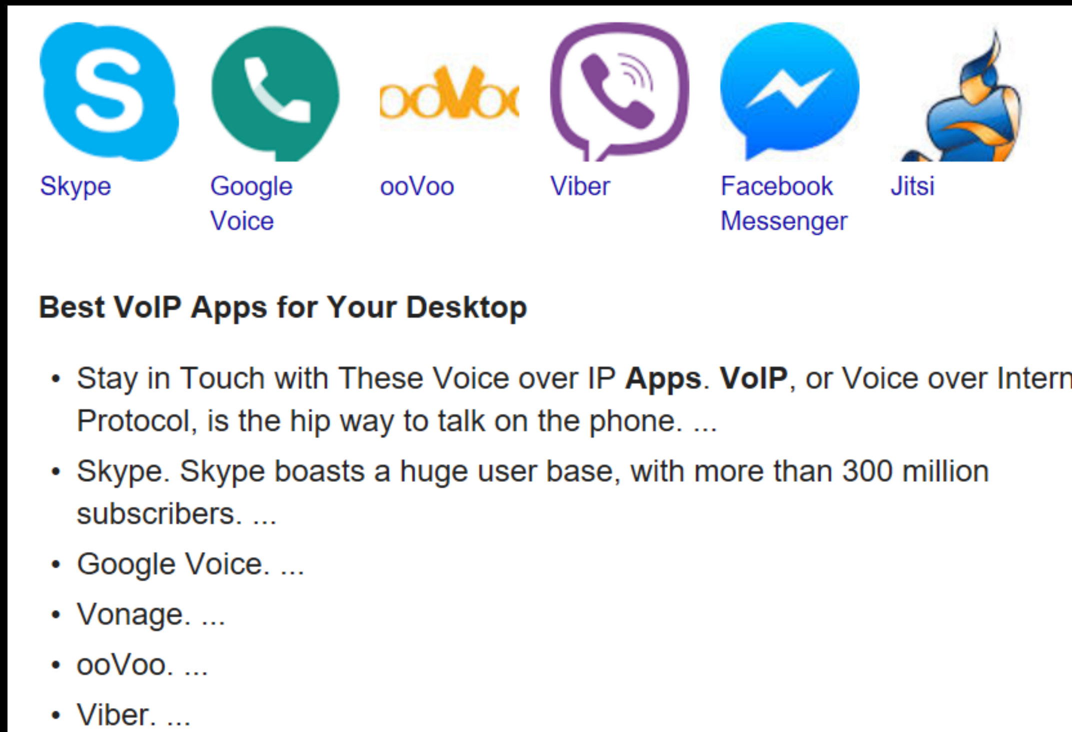
…etc

What applications are using VoIP?

This is a small snapshot of the most popular VoIP applications.

Not all of them use SIP, though:
Skype uses proprietary protocol

Viber does use SIP, so as Blink, Cisco IP Communication, Jitsi, Bria, Empathy,Linphone,X-Lite, Zoiper,Yahoo! Messenger…



Let’s talk about SIP

- SIP by default runs as a UDP service over the port 5060
- By default, it is not encrypted

- Full description of SIP protocol is given in the https://tools.ietf.org/html/rfc3261

- SIP structure is very similar to HTTP session structure (both request and response paradigm)

Structure of a SIP session

Similar to HTTP

Request (REGISTER vs GET)

```
REGISTER sip:192.168.0.116:5061 SIP/2.0
Call-ID: 2b0a036d62188707e8c1fa3f99d442eb@0:0:0:0:0:0:0:0
CSeq: 1 REGISTER
From: "demo-103" <sip:demo-103@192.168.0.116>;tag=fe23e8cf
To: "demo-103" <sip:demo-103@192.168.0.116>
Via: SIP/2.0/TLS 192.168.0.164:3565;branch=z9hG4bK-373232-13573379b4dc2c69a
Max-Forwards: 70
User-Agent: Jitsi2.10.5550Windows 10
Expires: 600
Contact: "demo-103" <sip:demo-103@192.168.0.164:3565;transport=tls;register
Content-Length: 0
```

Response (Unathorised

Return code 401)

```
SIP/2.0 401 Unauthorized
Via: SIP/2.0/TLS
192.168.0.164:3565;branch=z9hG4bK-373232-13573379b4dc2c69aa6994b76a28d8af;r
From: "demo-103" <sip:demo-103@192.168.0.116>;tag=fe23e8cf
To: "demo-103" <sip:demo-103@192.168.0.116>;tag=as174e6496
Call-ID: 2b0a036d62188707e8c1fa3f99d442eb@0:0:0:0:0:0:0:0
CSeq: 1 REGISTER
Server: Asterisk PBX 15.7.2
Allow: INVITE, ACK, CANCEL, OPTIONS, BYE, REFER, SUBSCRIBE, NOTIFY, INFO, P
Supported: replaces, timer
WWW-Authenticate: Digest algorithm=MD5, realm="asterisk", nonce="08e37204"
Content-Length: 0
```

Request (REGISTER vs GET)

```
REGISTER sip:192.168.0.116:5061 SIP/2.0
Call-ID: 2b0a036d62188707e8c1fa3f99d442eb@0:0:0:0:0:0:0:0
CSeq: 2 REGISTER
From: "demo-103" <sip:demo-103@192.168.0.116>;tag=fe23e8cf
To: "demo-103" <sip:demo-103@192.168.0.116>
Max-Forwards: 70
User-Agent: Jitsi2.10.5550Windows 10
```

Attributes of a SIP session

We will focus on attributes required to facilitate password attacks. These are: algorithm, method, username, realm, uri,response,nonce,{nc},{cnonce} and {qop}

```
SUBSCRIBE sip:demo-103@192.168.0.116 SIP/2.0
Call-ID: 7f8aa645e0eaa29432637916eacf4fac@0:0:0:0:0:0:0
CSeq: 2 SUBSCRIBE
From: "demo-103" <sip:demo-103@192.168.0.116>;tag=27f22122
To: "demo-103" <sip:demo-103@192.168.0.116>
Max-Forwards: 70
Contact: "demo-103" <sip:demo-103@192.168.0.164:3565;transport=tls;registering_acc=192_168_0_116>
User-Agent: Jitsi2.10.5550Windows 10
Event: presence.winfo
Accept: application/watcherinfo+xml
Expires: 3600
Via: SIP/2.0/TLS 192.168.0.164:3565;branch=z9hG4bK-373232-b62e3236d4729306c94af25ea7b34831
Authorization: Digest
username="demo-103",realm="asterisk",nonce="5ef0fb06",uri="sip:demo-103@192.168.0.116",response="a35726f18b7e4d8e62648dc299f28241",algorithm=MD5
Content-Length: 0
```

Why TLS/encryption?

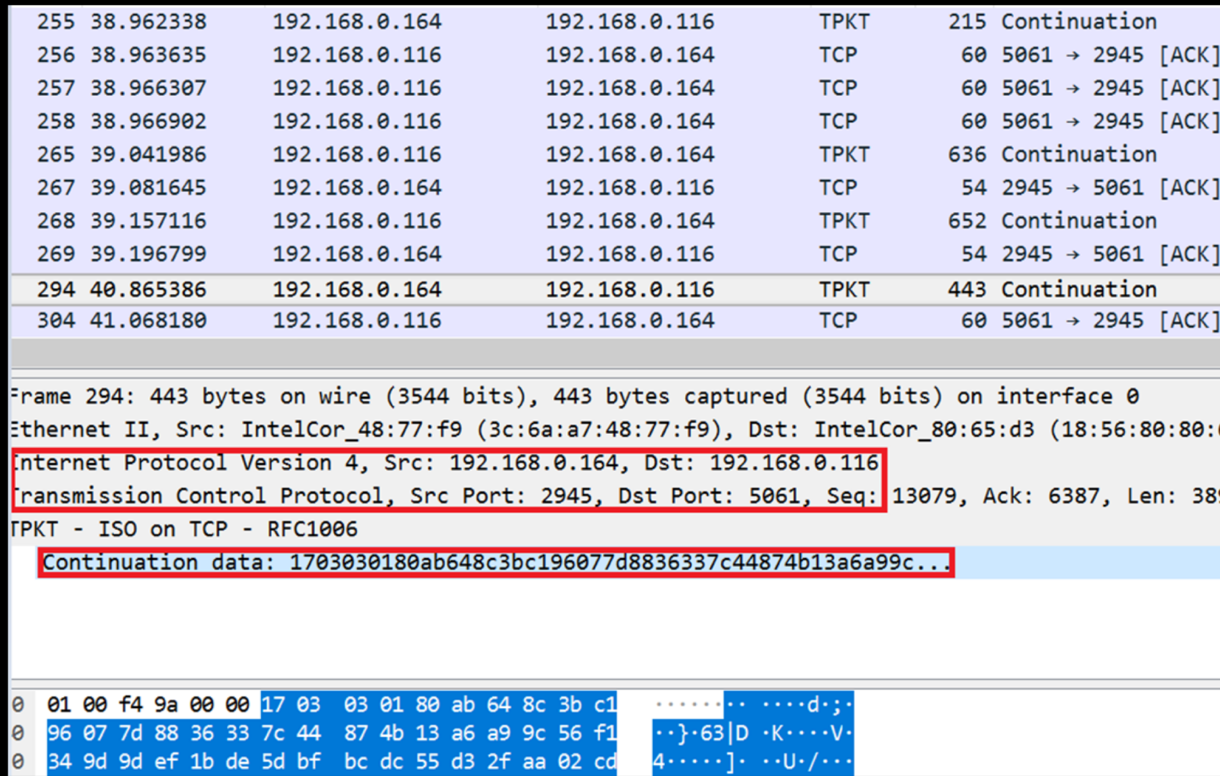
- wrapping SIP into TLS makes it more secure (HTTP vs HTTPS, POP3 vs POP3S, LDAP vs LDAPS etc.)
- interception of encrypted SIP will show obfuscated application layer payload
- only ip/tcp/udp header level information intelligible

Why TLS/encryption?

-challenges to pentesters that TLS presents – we want the application layer

Lower OSI layers

Application layer obfuscated



SIP –two aspects of attacks

1st aspect : interception + decryption

- -for unencrypted SIP sessions, one focuses only on interception
- -in our case, we need to do both

2nd aspect : SIP password cracking

- -for unencrypted SIP sessions, off-the-shelf tools available in Kali
- -in our case, we need to develop either:
    - -manual preparation of a file for sipcrack
    - -our own tool to streamline the cracking (<= chosen approach)

Attacking plaintext SIP passwords

-Kali with sipdump and sipcrack

-sipdump takes a pcap of a SIP session as input and generates a text file output for sipcrack

-sipcrack takes the text output from sipdump and performs password dictionary attack

```
root@kali:/projekti/mitm-relay# sipdump -h

SIPdump 0.2
---------------------------------------

Usage: sipdump [OPTIONS] <dump file>

       <dump file>    = file where captured logins will be written to

       Options:
       -i <interface> = interface to listen on
       -p <file>      = use pcap data file
       -m             = enter login data manually
       -f "<filter>"  = set libpcap filter

* Invalid arguments
root@kali:/projekti/mitm-relay# sipcrack -h

SIPcrack 0.2
----------------------------------------

Usage: sipcrack [OPTIONS] [ -s | -w <wordlist> ] <dump file>

       <dump file>   = file containing logins sniffed by SIPdump

       Options:
       -s            = use stdin for passwords
       -w wordlist   = file containing all passwords to try
       -p num        = print cracking process every n passwords (for -w)
                       (ATTENTION: slows down heavily)

* Invalid arguments
root@kali:/projekti/mitm-relay# 
```

Solution design-1st part (interception and decryption)

An idea of MITM occurred as one plausible attack vector

This is what we need to achieve:

- build a mechanism capable of intercepting and decrypting the TLS wrapped session
- search for some kind of protocol-agnostic proxy capable of decrypting TLS
- forward the traffic from this protocol-agnostic proxy to Burp so we can play with packets

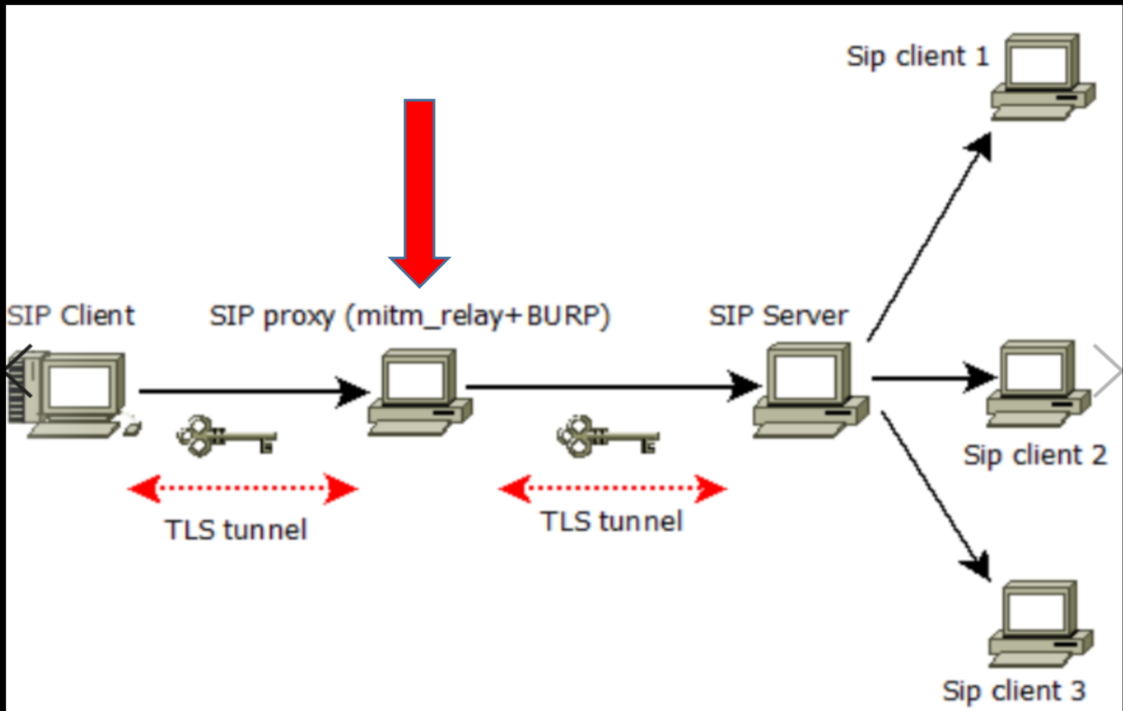
Solution design-1st part (interception and decryption)

- Burpsuite does that job No. 1, but only for HTTP(S) – it does not speak SIP or any other non-HTTP(S) protocols for that matter
- The Solution: mitm_relay.py (https://github.com/jrmdev/mitm_relay)

Solution design-1st part (interception and decryption)

-Topology design developed as below

-Key component: mitm_relay.py + Burpsuite running as SIP proxy on Kali
- you can have them on separate VMs too, also , no particular need for Kali – any linux will do, I guess



Chaining mitm_relay.py with Burp

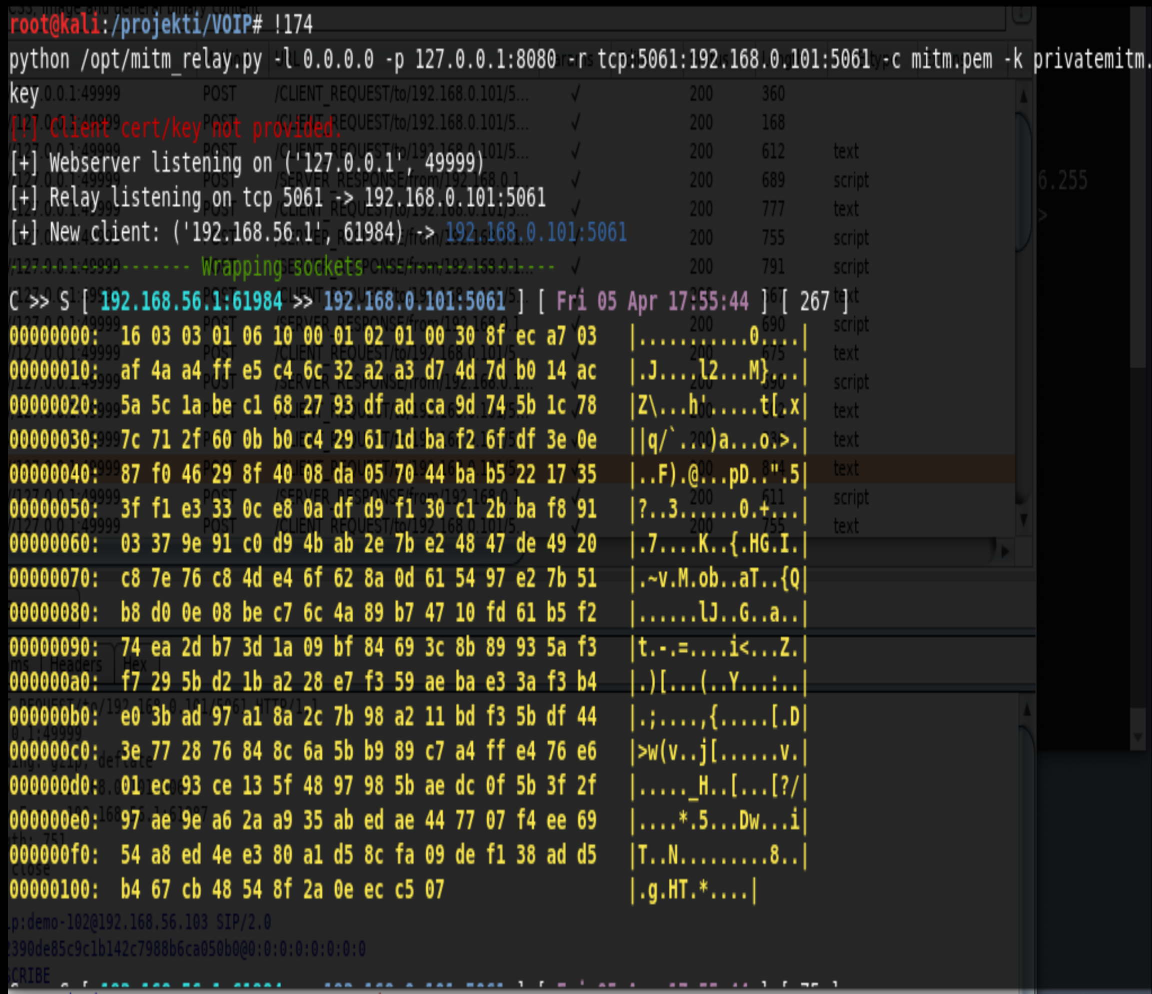
-l 0.0.0.0 mitm_relay.py listens on all interfaces

-p 127.0.0.1:8080 Burp runs on localhost , port 8080

-r tcp:5061:192.168.0.101:5061 relay all traffic on tcp 5061 port to final SIP server running on 192.168.0.101, port 5061

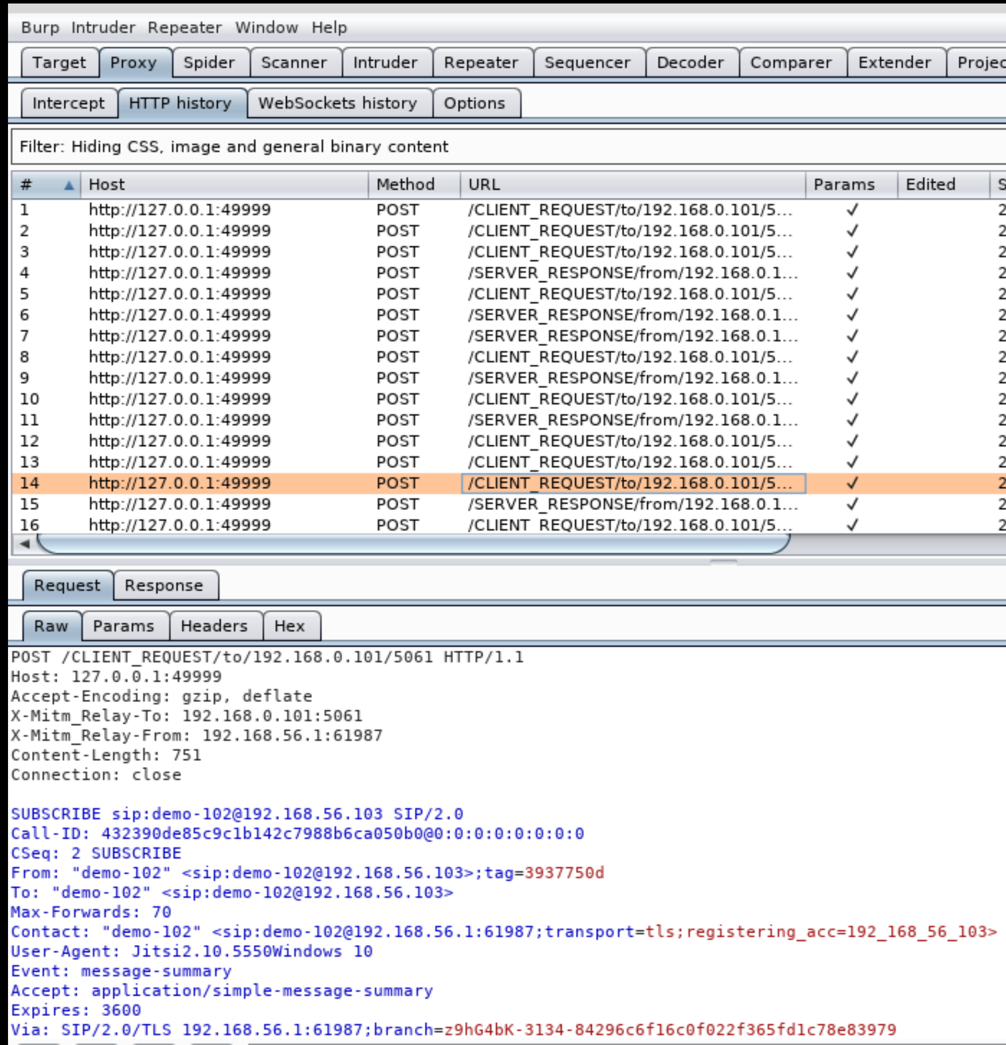
-c mitm.pem digital certificate for mitm_relay.py

-k privatemitm.key private key for mitm_relay.py



Chaining mitm_relay.py with Burp

- If we switch over to Burp, we can see decrypted SIP negotiation
- POST requests have embedded "/CLIENT_REQUEST/to/<IP>" and "/SERVER_RESPONSE/from/<IP>"
- that allows Burp to process SIP Sessions (it only transports stuff, does not really speak SIP)



Chaining mitm_relay.py with Burp

- Mechanics of the interception
- SIP client ->mitm_relay.py->Burpsuite->SIP server->SIP client 2

- NOTE: remember that now that we have Burp reading the SIP, several other attacks can be mounted :
  - -send SIP request to Burp Repeater,
  - -change call destinations,
  - -brute force destination numbers,
  - -change user agent fingerprint ,
  - -inject some funky headers/establish covert channel attack,
  - -spoof calling ID…

- Tampering in BURP is interesting, but out of scope of this research

Solution design - 2nd part (coding new app)

- Why is new app required –what about sipdump and sipcrack?

  -sipdump will not work here –we have dumped the decrypted session into a non-pcap format

  -sipdump has no way of importing the private key to decrypt the captured wireshark pcap session

  -we can decrypt wireshark pcap, remember? – we possess the private key for mitm_relay.py

- What is new app doing?

  -new app will process the mitm_relay.py dump which is more-less text based file and will extract all authentication attributes and perform password dictionary-based attack

Solution design - 2nd part (coding new app)

- Functional mapping of sipdump+sipcrack into sipcrack2
- Streamline mitm_relay dump parsing with password cracking
- How do we crack digest algorithm?

    -https://www.ietf.org/rfc/rfc2069.txt later ammended by RFC 2617

    -{qop},{nc},{cnonce} increase the variability of hashing but will still not protect against our attack and all these attributes can be intercepted and decrypted

Solution design - 2nd part (coding new app)

- Digest authentication algorithm

- If {qop},{cnonce} and {nc} are not defined (RFC2069) then

  H1=MD5(username:realm:password)
  H2=MD5(method:uri)
  Response=MD5 (H1:nonce:H2)

  Else if {qop},{cnonce} and {nc } are defined (RFC2617) then

  Response=MD5(H1:nonce:nc:cnonce:qop:H2)

  https://github.com/adenosine-phosphatase/sipcrack2

Final thoughts

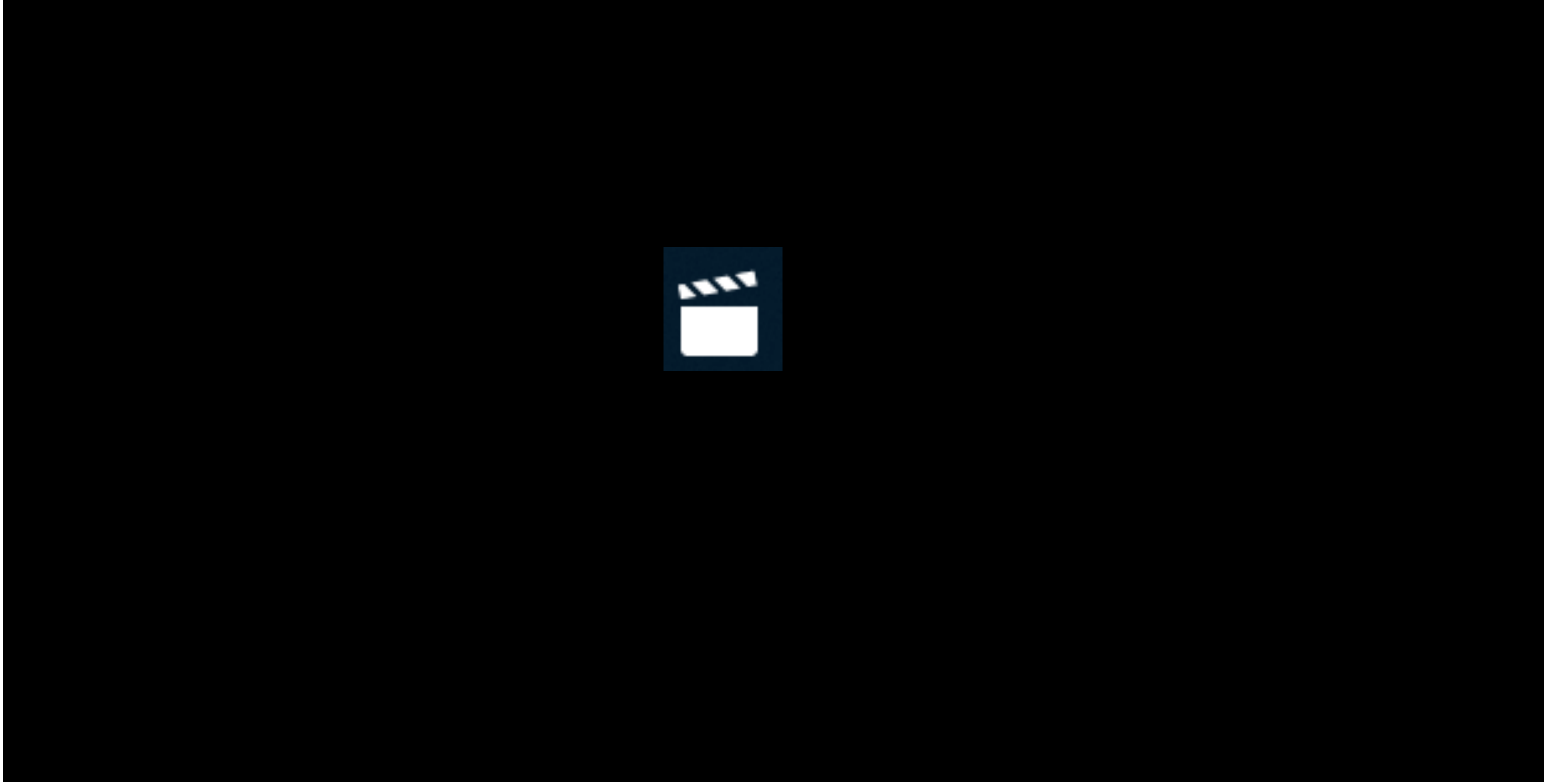
- Development
  sipcrack2 is for now just a linux version, hope to release Windows version with CUDA/multithreading & parallel processing in a near future

- How realistic/difficult is the attack?
  The attack shown is relatively difficult to implement (ARP poisoning required to redirect the traffic from legitimate proxy to the attacker)

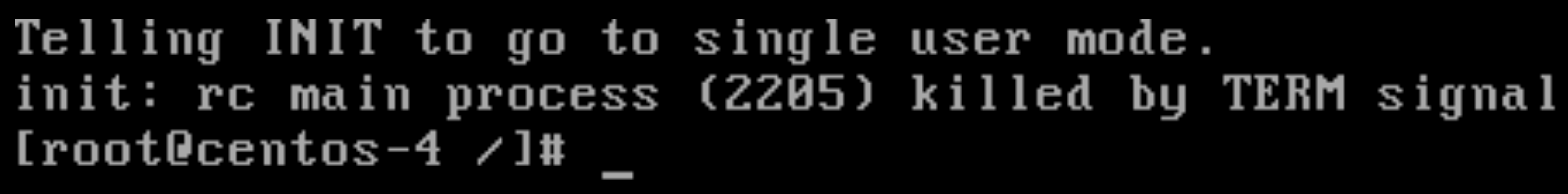
- Recommendations
  - -use strong passwords
  - -do not use self-signed certificates
  - -use client side certificate in addition to server

- Risk rating proposed: Medium

Demo



Questions?



Shutting down