SharkFest '19 Europe

Automate your analysis

TShark, the Swiss army knife

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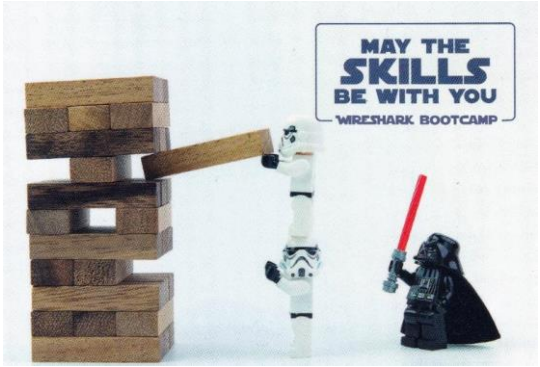
Rabobank

Rabobank

About me?

Rabobank

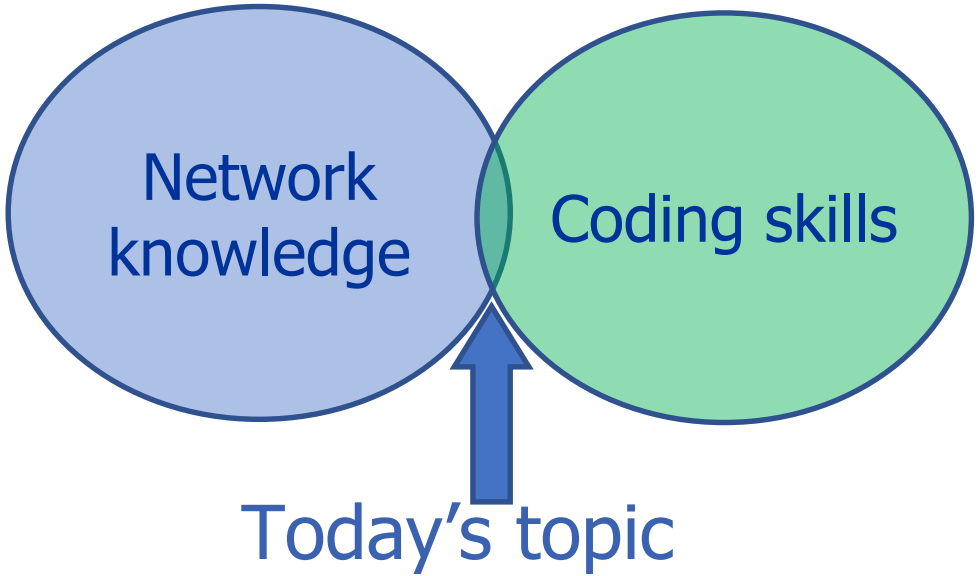
KEEP
CALM
and
ANALYZE
PACKETS



Topics

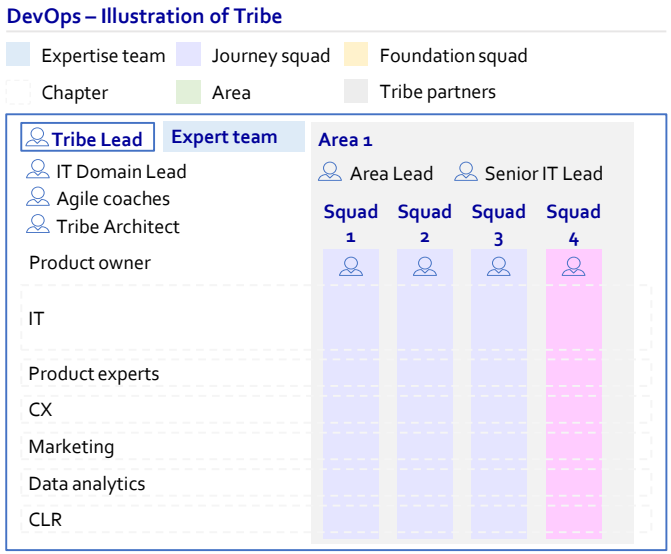
- Why did *we* automate analysis
- How did *we* automate
  - Overview of the tool
  - Design concepts & lessons learned
- Available command line options
- Coding samples
  - How-to's

Area of expertise

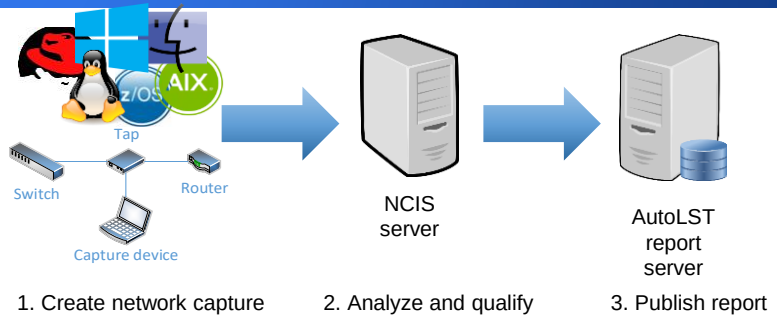


Why did *we* automate

- Need for fast feedback on development activities on stability and performance
  - Application monitoring incomplete
- DevOps – many small teams
  - Need: fall back to expert team
- Repetitive work
  - Part of performance load testing checking if issues were fixed
- Shift towards HTTP/TLS
  - Micro services & cloud based



How did *we* automate



Steps:

1. Upload pcap (can be automated)
2. Sanity check
   - Reject: corrupted files, too many snapped packets, too low traffic volume, high dropped packet rate
3. Split in known protocols/applications – simplifies analysis
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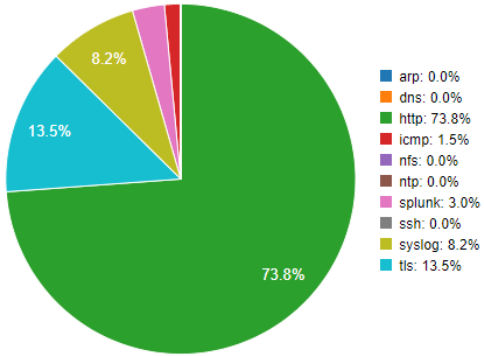
5. Send results to report server (JSON format)

Demo

Demo url

Global (all combined) summary

Traffic by type graph:



SHOW DETAILED INFORMATION | SHOW TYPE DESCRIPTIONS

Result summary

	positive	minor	major	critical	undetermined	none
Occurrence	3	5	3	5	0	0

TShark output options

Most used text output options:

1. -T fields -e *field* …

   Line based output, selected fields only, tab separated

2. -O *filter*

   Multi line tree view, context of fields

3. -z io,stat,*interval,filter*,… -q

   Statistics per interval, for selected filter(s)

Generate hosts file from pcap

Nowadays reverse DNS lookups does *not* provide useful hostnames because:

- Website is hosted in the cloud
- Dynamic-DNS used and DNS name has been changed between the time of capturing and analyzing

Solution:

Get the hostnames actually used out of the pcap file *itself*

and launch tshark with '-H <input hosts file>' option or save as the personal *hosts* file for wireshark

Generate hosts file from pcap

```
tshark -r filename.pcap -Tfields -e ipv6.dst -e ip.dst
  -e http.host
  -e tls.handshake.extensions_server_name
  -e gquic.tag.sni
  -e dhcp.fqdn.name
  -Y 'http.host||tls.handshake.extensions_server_name
      ||gquic.tag.sni||(dhcp.fqdn.name&&
      !(ip.dst==255.255.255.255))' |
sort -ui > hosts.txt
tshark -r filename.pcap -H hosts.txt
   -w file-with-hosts.pcapng -P -F pcapng -W n
```

TShark output options

Most used text output options:

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   Line based output, selected fields only, tab separated

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   Multi line tree view, context of fields

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   Statistics per interval, for selected filter(s)

TShark -O example

```
tshark -r tls.pcapng -O tls -2R tls.handshake.type==11 -c 1 |
  grep -A3 notBefore
                notBefore: utcTime (0)
                    utcTime: 16-07-25 07:54:21 (UTC)
                notAfter: generalizedTime (1)
                    generalizedTime: 2050-06-02 07:54:21 (UTC)

                notBefore: utcTime (0)
                    utcTime: 17-12-09 13:54:53 (UTC)
                notAfter: utcTime (0)
                    utcTime: 21-12-09 14:04:53 (UTC)
  -T fields -e x509af.utcTime -e x509af.generalizedTime
```

Certificate

x509af.utcTime

x509af.generalizedTime

Which is before and after?

TShark output options

Most used text output options:

1. -T fields -e *field* …

   Line based output, s

2. -O *filter*

   Multi line tree view,

3. -z io,stat,*interva*

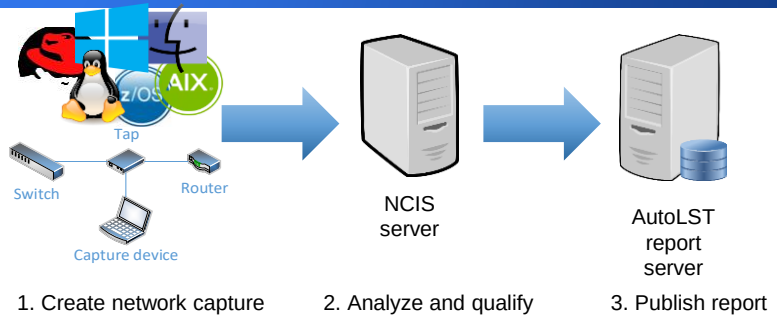
   Statistics per interv

```
================================================================================
| IO Statistics                                                                |
|                                                                              |
| Duration: 13.3 secs                                                          |
| Interval: 13.3 secs                                                          |
|                                                                              |
| Col 1: FRAMES                                                                |
|     2: BYTES                                                                 |
|     3: COUNT(frame.time_delta)frame.time_delta<0                             |
|     4: COUNT(tcp.analysis.ack_lost_segment)tcp.analysis.ack_lost_segment     |
|     5: COUNT(tcp.analysis.lost_segment)tcp.analysis.lost_segment             |
|     6: COUNT(frame.len)frame.len>frame.cap_len                               |
|------------------------------------------------------------------------------|
|               |1       |2          |3      |4      |5      |6      |        |
| Interval      | FRAMES |   BYTES   | COUNT | COUNT | COUNT | COUNT |        |
|-------------------------------------------------------------------|        |
|  0.0 <> 13.3  | 103120 | 50733071  |    96 |  8371 |  7748 | 35238 |        |
================================================================================
```

TShark -z io,stat from Perl

```
my @command = ('tshark', '-r', $file, '-q', '-n'
   , '-z', 'io,stat,0' # generate IO stats, totals only
   . ',FRAMES,BYTES'   # frame & byte totals
   . ',COUNT(frame)frame.time_delta<-0.0005'
      # negative delta is a sign of dropped packets in kernel
   . ',COUNT(frame)frame.len>frame.cap_len'); # snapped!
open(my $fh, "-|", @command) or die "Command failed $!";
while (<$fh>) {
   next if not /<>/; # ignore 'human readable' output
   tr/|<>\r\n//d;    # remove formatting
   my @columns = split ' '; # split AWK style
   print join("\t", @columns), "\n"; # process fields…
} close($fh);
```

How did *we* automate



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Split in known protocols

Steps:

1. Detect protocol/application by packet data
   - Avoid need for config files, more robust
2. Create pcap using filter
3. Create new pcap using ‘not’ filter
4. Repeat steps 1-3 for next protocol/application

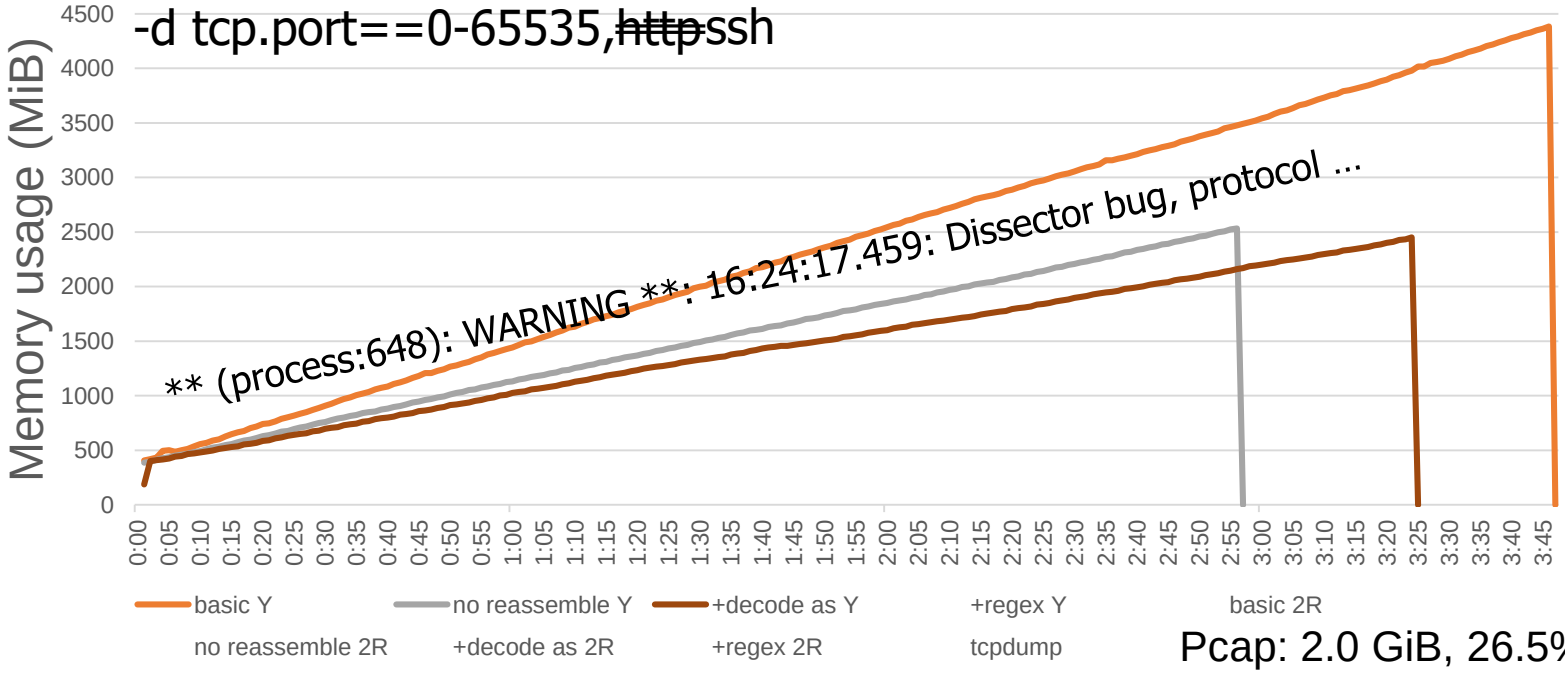
Requirements for tool

- Network capture should contain enough data for proper statistical analysis, thus preferably:
  - Capture duration at least 5 minutes
  - Not ‘pre filtered’
- Process pcap with file size up to 5 Gbyte
  - What server configuration needed?

Memory usage and speed

tshark -n -T fields -e ip.src -e tcp.srcport -Y http.response
-o tcp.desegment_tcp_streams:FALSE
-d tcp.port==0-65535,~~http~~ssh

1 core @ 100%

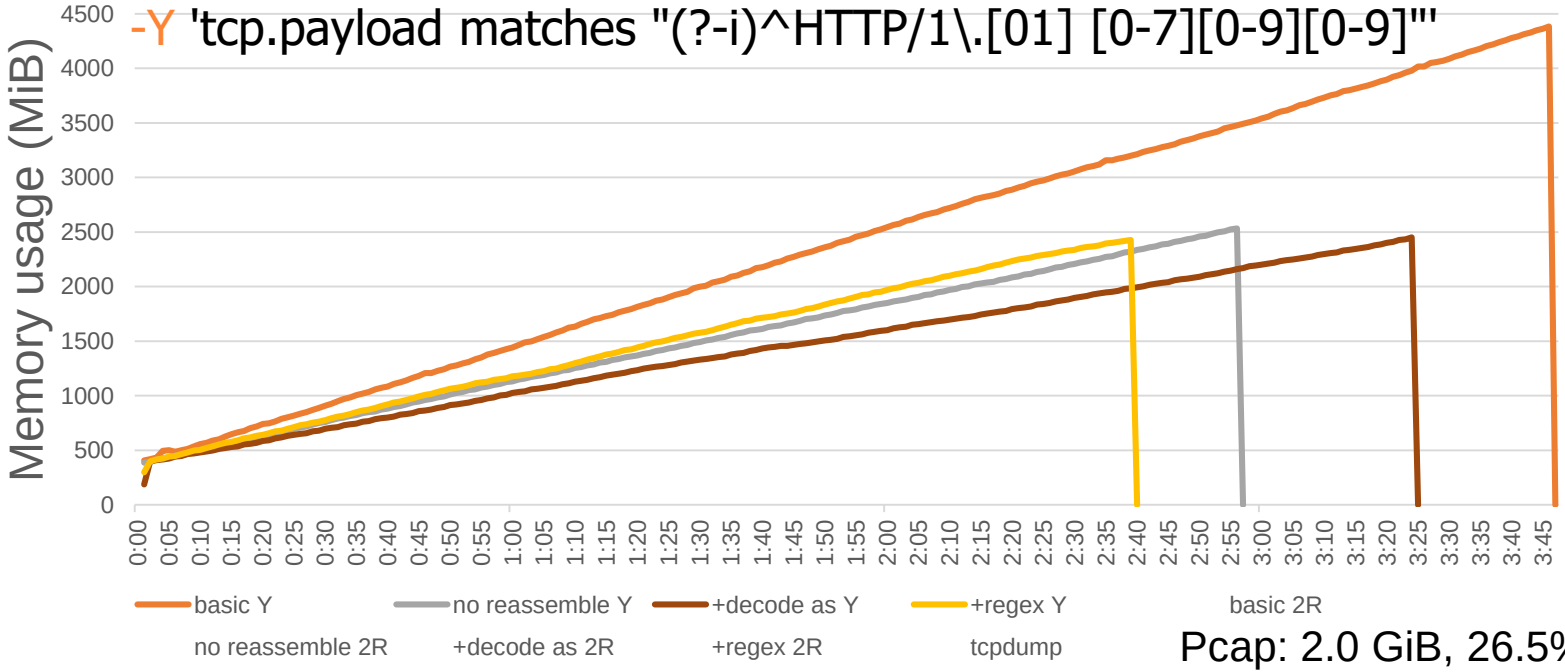


Pcap: 2.0 GiB, 26.5% HTTP

Memory usage and speed

tshark -n -T fields -e ip.src -e tcp.srcport
-o tcp.desegment_tcp_streams:FALSE -d tcp.port==0-65535,ssh
-Y 'tcp.payload matches "(?-i)^HTTP/1\.[01] [0-7][0-9][0-9]"'

1 core @ 100%

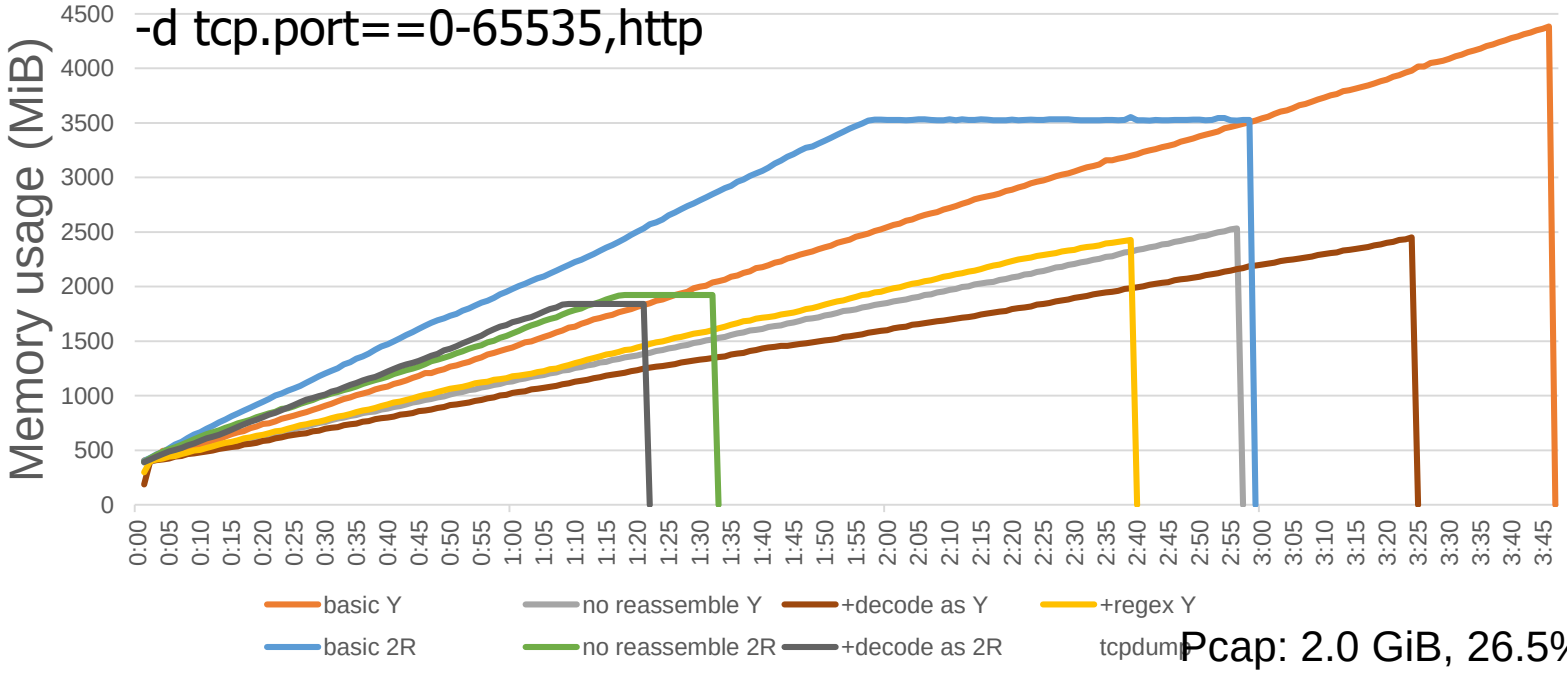


Pcap: 2.0 GiB, 26.5% HTTP

Memory usage and speed

tshark -n -T fields -e ip.src -e tcp.srcport -2R http.response
-o tcp.desegment_tcp_streams:FALSE
-d tcp.port==0-65535,http

1 core @ 100%



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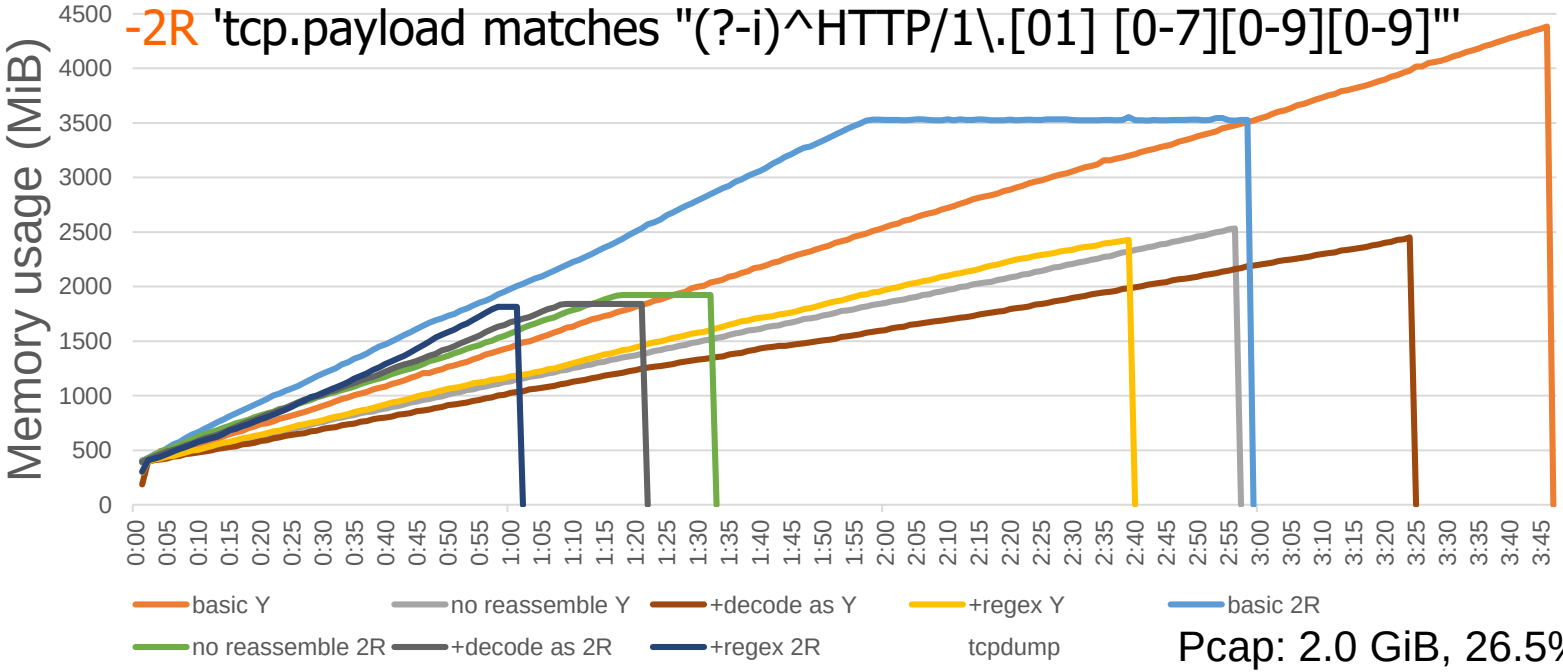

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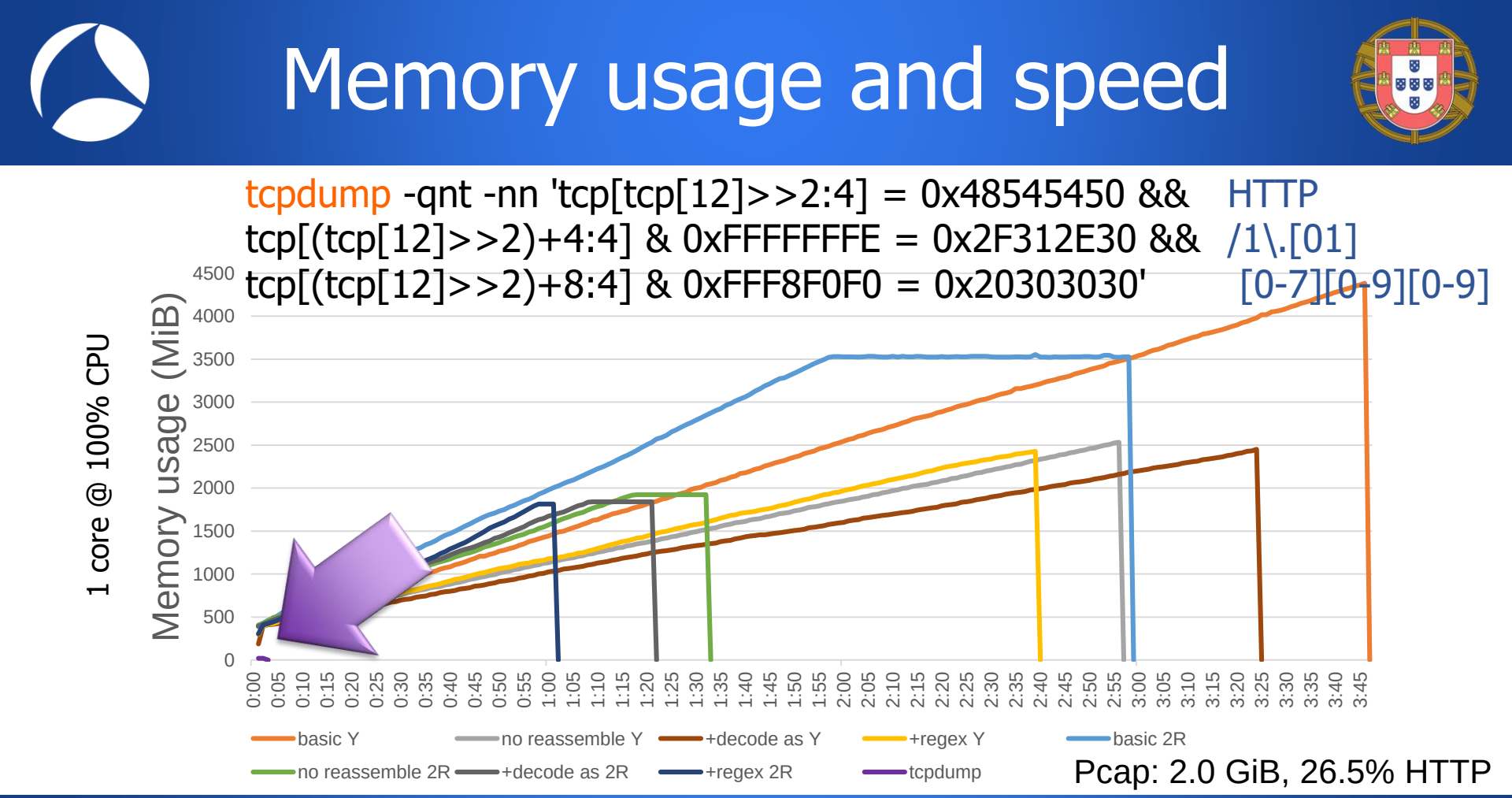


TShark versus tcpdump
for pre-processing

TShark

+ Elaborate filtering options
+ Flexible output
+ Output statistics

– Slow
– Memory hog
– File size limited by available memory

Tcpdump

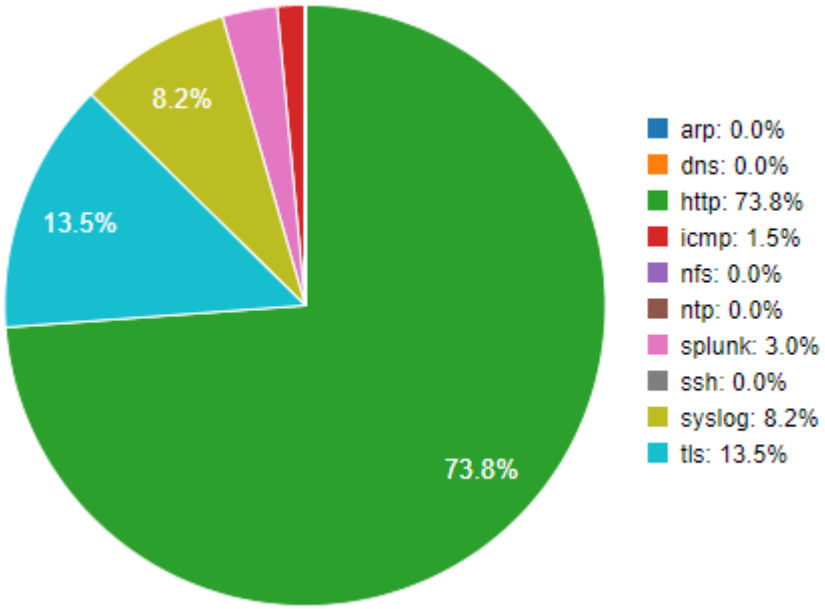
BPF: frame by frame filtering:

+ Fast
+ Unlimited file size
+ Small memory footprint

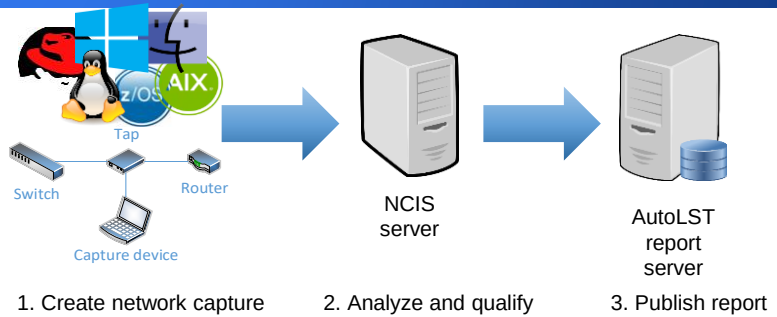
– Limited output options
– Pcap and pcapng only

Graph protocols

Example:



How did *we* automate



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Process stream by stream

To process data stream by stream, sort by stream & time

```
tshark -n -r filename.pcap -T fields
  -e tcp.stream -e frame.time_epoch
  -e ip.src -e _ws.col.Info -Y tcp |
sort -k 1,1n -k 2,2n
```

```
0   1528205116.256929000   172.18.224.71   56293 → 80 [SYN, ECN, CWR] Se
0   1528205116.258545000   172.17.184.32   80 → 56293 [SYN, ACK] Seq=0 A
0   1528205116.258588000   172.18.224.71   56293 → 80 [ACK] Seq=1 Ack=1
0   1528205116.258769000   172.18.224.71   POST /cgi-bin/Sharkfest2019al
0   1528205116.258825000   172.18.224.71   56293 → 80 [ACK] Seq=354 Ack=
0   1528205116.258826000   172.18.224.71   56293 → 80 [ACK] Seq=1734 Ack
```

TShark in Perl example

```
my $command = "tshark -r '$file' -n -T Fields"
   . " -e tcp.stream -e frame.time_epoch"
   . " -e ip.src -e _ws.col.Info -Y tcp"
   . "| sort -k 1,1n -k 2,2n"; # sort by column 1 & 2 numeric
my $tcpnr = -1; # to detect new TCP stream
open(my $fh, "-|", $command) or die "Command failed $!";
while (<$fh>) {
   my ($tcp, $time, $ipsrc, $info) = split "\t";
   if ($tcp != $tcpnr) { new_tcp_stream(); $tcpnr = $tcp; }
   # handle fields here…
}
close($fh);
new_tcp_stream() if $tcpnr >= 0;
```

Filter out incomplete streams

```
#!/bin/bash
options="-o tcp.desegment_tcp_streams:FALSE -d tcp.port==0-
  65535,ssh"
output=$(tshark -r "$1" $options -Tfields -2R "tcp.flags & 7"
  -e tcp.stream -e frame.number -e tcp.flags.syn |
  sort -k 1,1n -k 2,2n |
  awk -F "\t" 'BEGIN { tcps = -1; filter = "" }
  { if ($1 != tcps) { tcps = $1; syn = 0 } # new stream
    if ($3) syn = 1; else                  # if SYN
      { if (syn) filter = filter " " $1    # else FIN|RST
        syn = 0 } }
  END {if (filter!="") print "tcp.stream in {" filter "}" }')
tshark -r "$1" -w "$2" $options -2R "$output"
```

FIN/SYN/RST

Command line length limitation

Linux: About 2 Mbyte

to get the exact value use the command:

```
echo $(( $(getconf ARG_MAX) - $(env | wc -c) - $(env | wc -l) * 8 - 8 )) # = ARG_MAX - environment array size
```

More info: **man** execve

Mac OS: About 256 kbyte, same method as Linux

Windows:

CreateProcess & PowerShell: 32767 (wide) characters

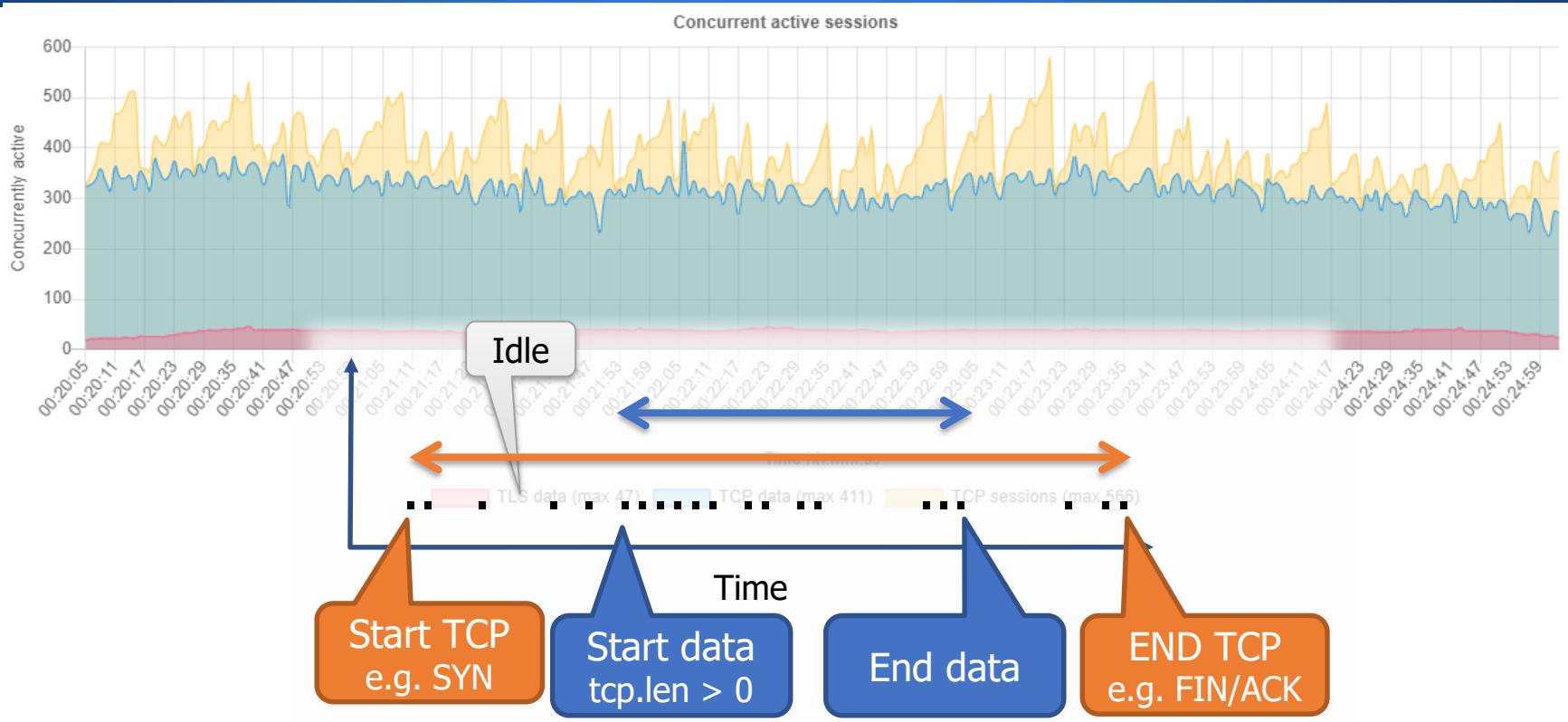
CMD: 8191 wchars (before Windows XP: 2047 wchars)

Filter out incomplete streams

Optimize by using range operator, e.g.: `tcp.stream in { 3..99 123 }`

```
    else { if (syn) arr[$1] = 1; syn = 0 } } # store in array
  END { filter = ""
    for (i = 0; i <= tcps; i++)
      if (i in arr) { # if complete TCP stream found
        j = i + 1; while (j in arr) j++ # look for range
        j-- # now range is from i to j inclusive
        if (i+2 <= j) { filter = filter " " i ".." j; i = j }
        else filter = filter " " i
      }
    if (filter != "") print "tcp.stream in {" filter "}" }')
tshark -r "$1" -w "$2" $options -2R "$output"
```

Plot concurrent sessions



Plot concurrent sessions (1)

```
#!/bin/bash
tshark -r "$1" -n2R tcp -d tcp.port==0-65535,ssh -T fields
   -e tcp.stream -e frame.time_epoch -e tcp.len |
sort -k 1,1n -k 2,2n |
awk 'BEGIN { tcp = -1; OFS=FS="\t"; RS="\r?\n";
     timemin = 1e11; timemax = 0 }
   $1 != tcp { new_tcp(); tcp = $1; start = $2; datastart = 0}

   $3 > 0 { # if tcp.len > 0
     if (datastart == 0) datastart = $2
     dataend = $2 }

   { end = $2 }
```

```
3       1547594405.013646000    0
3       1547594405.013658000    0
3       1547594405.014117000    0
3       1547594405.014124000    1460
3       1547594405.014134000    0
3       1547594405.014147000    2
3       1547594405.014150000    0
4       1547594405.014386000    1655
5       1547594405.015258000    0
5       1547594405.015266000    0
```

Plot concurrent sessions (2)

```
function new_tcp() { # note: all times in epoch format
  if (tcp < 0) return
  end = int(end); start = int(start) #round down to seconds
  for(i = start; i <= end; i++) arr[i]++ # fill sec array
  if (timemin > start) timemin = start
  if (timemax < end  ) timemax = end
  if (datastart != 0) {
    dataend = int(dataend); datastart = int(datastart)
    for(i = datastart; i <= dataend; i++) darr[i]++ } }
 END {
  new_tcp(); print "Time", "TCP sessions", "TCP data"
  for (idx = timemin; idx <= timemax; idx++)
    print strftime("%T", idx), arr[idx], darr[idx]}'
```

Plot sessions summary

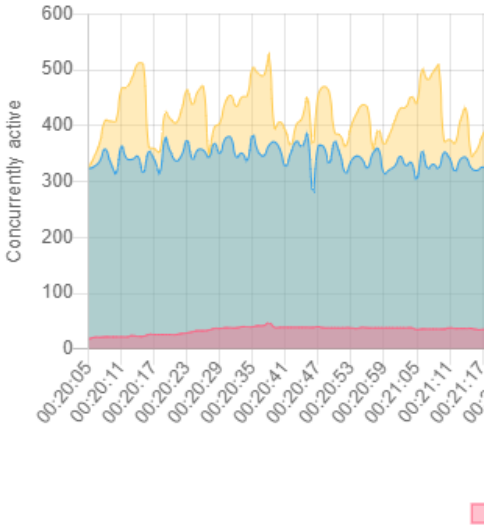
From sorted TShark output

```
3       1547594405.013646000    0
3       1547594405.013658000    0
3       1547594405.014117000    0
3       1547594405.014124000    1460
3       1547594405.014134000    0
3       1547594405.014147000    2
3       1547594405.014150000    0
4       1547594405.014386000    1655
5       1547594405.015258000    0
5       1547594405.015266000    0
5       1547594405.015478000    0
5       1547594405.015485000    2018
5       1547594405.015492000    0
6       1547594405.015593000    0
6       1547594405.015600000    0
7       1547594405.015696000    2211
6       1547594405.016513000    0
6       1547594405.016528000    1972
```

to data table

Time	TCP sessions	TCP data
00:20:05	304	302
00:20:06	318	301
00:20:07	342	309
00:20:08	381	330
00:20:09	379	307
00:20:10	380	288
00:20:11	438	334
00:20:12	436	308
00:20:13	452	306
00:20:14	480	314
00:20:15	477	285
00:20:16	329	319
00:20:17	315	296
00:20:18	309	282
00:20:19	379	341
00:20:20	368	319
00:20:21	362	303

and to the graph



TLS (encryption) statistics

Determining ratio resumed versus full handshakes

- For best performance use resumed handshakes
- Setting up TLS is difficult
  - A server falling back to full handshakes often goes unnoticed until performance related incidents occur
  - Typically such change is not visible in application log
  - Example: Java upgrade at client side only enabling TLS Extended Master Secret extension (RFC 7627)

Ratio resumed / full handshakes

```
tshark -z 'io,stat,0,COUNT(tls.resumed)
  tls.resumed,COUNT(tls.handshake.type)
  tls.handshake.type==1' -nq -r tls.pcap
```

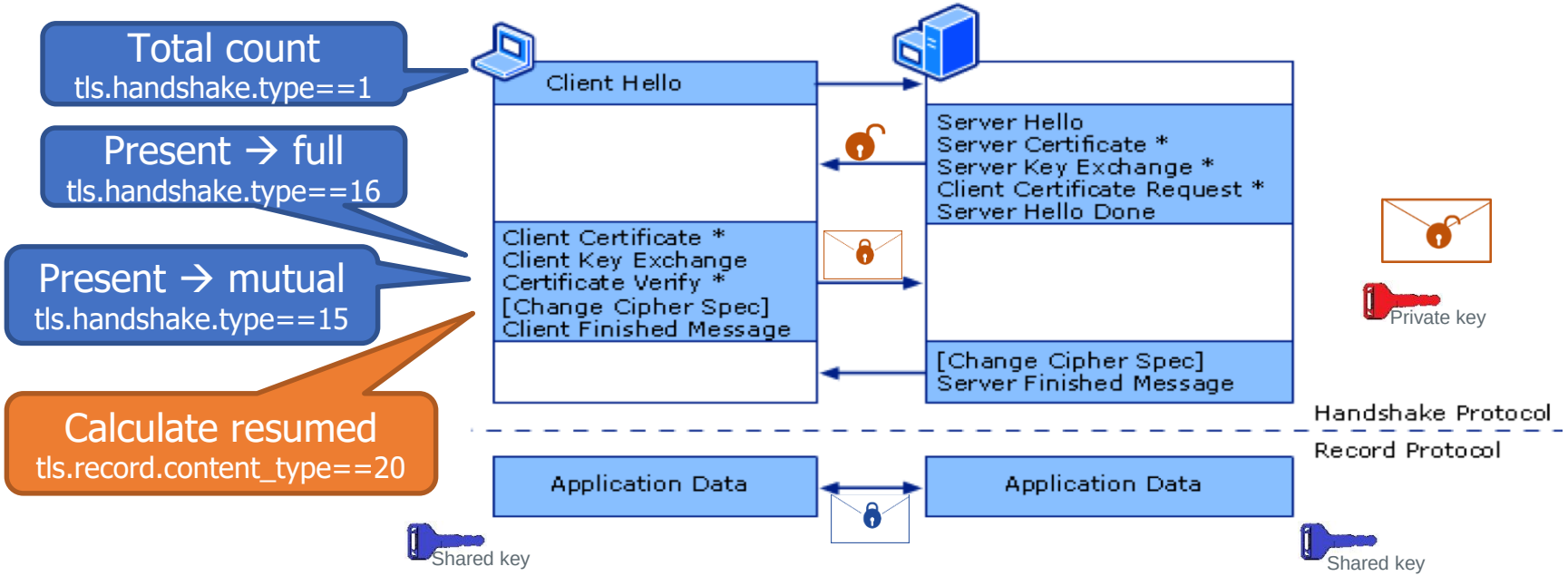
```
==================================================================
| IO Statistics                                                  |
|                                                                |
| Duration: 504.5 secs                                           |
| Interval: 504.5 secs                                           |
|                                                                |
| Col 1: COUNT(tls.resumed)tls.resumed                           |
|     2: COUNT(tls.handshake.type)tls.handshake.type==1          |
|----------------------------------------------------------------|
|                  |1        |2        |                         |
| Interval         | COUNT   | COUNT   |                         |
|------------------------------------|                           |
|   0.0 <> 504.5   |   770   |  7291   |                         |
==================================================================
```

Resumed, since v3.0.0

ClientHello

TLS statistics

Ratio resumed/full/mutual TLS handshakes (<v3.0)



TLS handshakes

tls

Src port	Dst port	Protocol	TCP stream	Bytes in Flight	Length	Info
42739	443	TLSv1	0	95	161	Client Hello
443	42739	TLSv1	0	1448	1514	Server Hello
443	42739	TLSv1	0	905	971	Certificate, Server Hello Done
42739	443	TLSv1	0	267	333	Client Key Exchange
42739	443	TLSv1	0	43	109	Change Cipher Spec, Finished
443	42739	TLSv1	0	43	109	Change Cipher Spec, Finished
42739	443	TLSv1	0	222	288	[TLS segment of a reassembled PDU]
42739	443	HTTP/XML	0	1521	1365	POST /ta/ HTTP/1.1
443	42739	TLSv1	0	25	91	Hello Request
42739	443	TLSv1	0	123	189	Client Hello
443	42739	TLSv1	0	1448	1514	Server Hello
443	42739	TLSv1	0	2648	1514	Certificate [TCP segment of a reassembled
443	42739	TLSv1	0	311	377	Certificate Request, Server Hello Done
42739	443	TLSv1	0	4027	1197	Certificate, Client Key Exchange
42739	443	TLSv1	0	283	349	Certificate Verify
42739	443	TLSv1	0	305	88	Change Cipher Spec
42739	443	TLSv1	0	342	103	Finished
443	42739	TLSv1	0	59	125	Change Cipher Spec, Finished
443	42739	TLSv1	0	1507	1514	[TLS segment of a reassembled PDU]
443	42739	HTTP/XML	0	384	450	HTTP/1.1 200 OK

Count handshake

Full handshake

Renegotiate request due to Step Up Authentication

Count handshake

Mutual handshake

Normally encrypted

TLS ciphers used

- ClientHello contains ciphers supported
- ServerHello contains the selected cipher

```
-Y tls.handshake.type==2 -e tls.handshake.ciphersuite
```

Outputs decimal number

Create conversion table:

```
curl -k https://www.iana.org/assignments/tls-parameters/tls-parameters-4.csv | awk -F '[",]+' '/^"0x..,0x..",[^RU]/ { print $2 substr($3, 3) " => \"" $4 "\","; c++ }
END { print "# Count:", c }'
```

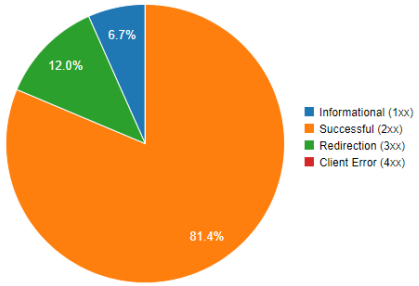
```
0x0000 => "TLS_NULL_WITH_NULL_NULL",
0x0001 => "TLS_RSA_WITH_NULL_MD5",
0x0002 => "TLS_RSA_WITH_NULL_SHA",
0x0003 => "TLS_RSA_EXPORT_WITH_RC4_40_MD5",
```

HTTP statistics

- Take a look at `tshark -z http,stats`
- And other `-z http`…
- Sample code behind this report

HTTP responses

HTTP rsponses by type



HTTP version

HTTP versions used by category

Request	Response	Version	Count	Percent
DELETE		HTTP/1.1	1093	1.12%
GET		HTTP/1.1	76990	78.7%
HEAD		HTTP/1.1	1207	1.23%
OPTIONS		HTTP/1.1	1204	1.23%
POST		HTTP/1.1	16204	16.6%
PUT		HTTP/1.1	1081	1.11%
	100 Continue	HTTP/1.1	6963	6.65%
	200 OK	HTTP/1.1	85168	81.4%
	302 Found	HTTP/1.1	12555	12%
	405 Method Not Allowed	HTTP/1.1	4	0.00382%

HTTP stats in Perl (1)

```
my $command = "tshark -r '$file' -n -T Fields "
   . " -e http.request.version -e http.request.method"
   . " -e http.response.version -e http.response.code"
   . " -e http.response.phrase"
   . " -Y 'http.request||http.response'";
my %stats; # init associative array
open(my $fh, "-|", $command) or die "Command failed $!";
while (<$fh>) { chomp;
   my ($cver, $cmethod, $sver, $scode, $stext) = split "\t";
   $stats{requests}{"$cver $cmethod"}++ if $cver ne "";
   $stats{responses}{"$sver $scode $stext"}++ if $sver ne "";
}
close($fh);
```

HTTP stats in Perl (2)

```
# print results
foreach my $id(sort keys %stats) {
   my $tot = 0;
   foreach (values %{$stats{$id}}) { $tot += $_ }
   print "$id:\n";
   foreach my $ind(sort keys %{$stats{$id}}) {
        printf "%#.3g%% %6d %s\n", $stats{$id}{$ind}/$tot*100,
               $stats{$id}{$ind}, $ind
   }
}
```

```
Requests:
0.00511%      5 HTTP/1.0 GET
0.00511%      5 HTTP/1.0 POST
1.12%      1093 HTTP/1.1 DELETE
78.7%     76985 HTTP/1.1 GET
1.23%      1207 HTTP/1.1 HEAD
1.23%      1204 HTTP/1.1 OPTIONS
16.6%     16199 HTTP/1.1 POST
1.11%      1081 HTTP/1.1 PUT
Responses:
```

Thank you

Thank you. Questions?

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Extra slides...

Wireshark command line

Did you know Wireshark has useful command line options too?

Read the online help or .html file in the program directory.

For example:

wireshark -r "my example.pcapng" ← open this file

-o tls.keylog_file:"my example.key" ← override config with this setting

-Y "tls && http" ← start with this display filter

Other command line tools

capinfos

- Shows properties of a pcap

editcap

- Filter time frame from large pcap
- Snap or chop packets
- Deduplicate
- Split in smaller files
- Convert file format
- Inject secrets (3.0)

mergecap

- Sew pcaps together

dumpcap

- Create network captures

SSLKEY capture & analyse (Windows)

```
rem Capture with SSLKEYLOGFILE - AU Luyer - 2018-09-10
set timestamp=%DATE:/=-%_%TIME::=-%
start /realtime "Dumpcap - stop with Control-C" ^
   "%ProgramFiles%\Wireshark\dumpcap" -q -i1 -i2 -w "trace-%timestamp%.pcap"
rem make sure the browser is not already running (in the background)...
taskkill /f /im chrome.exe
timeout 3

rem Set logfile. Must be absolute path!
set SSLKEYLOGFILE=%CD%\key-%timestamp%.log
start "Chrome-tls" "%ProgramFiles%\Google\Chrome\Application\chrome.exe" ^
   --disable-http2 https://sharkfesteurope.wireshark.org/

rem Using option tls.keylog_file allows for temporary use without altering
   the configuration.
echo start "Wireshark" "%ProgramFiles%\Wireshark\wireshark.exe" ^
   -r "trace-%timestamp%.pcap" -o tls.keylog_file:"key-%timestamp%.log" ^
   -Y "tls && http" > "start-wireshark-%timestamp%.cmd"
```

SSLKEY capture & analyse (Linux)

```
#!/bin/bash
# Capture with SSLKEYLOGFILE - AU Luyer - 2018-09-10
timestamp=$(date +%F_%H-%M-%S)
pcapfile=trace_$timestamp.pcap
keylogfile=keys_$timestamp.log

sudo nice -n -18 dumpcap -B 16 -q -i any -w - > $pcapfile &
# -w - > == workaround "Permission denied" bug.
echo $!
sleep 3

SSLKEYLOGFILE=$(realpath $keylogfile) firefox
   https://sharkfest.wireshark.org/ &
# Logfile must be absolute path!

script=start_wireshark_$timestamp.sh
echo "wireshark -r $pcapfile -o tls.keylog_file:$keylogfile -Y 'tls &&
   (http||http2)' &" > $script && chmod +rx $script
echo "Stop capture with: sudo pkill dumpcap"
```

Embedding decryption secrets in a pcapng file

Since Wireshark 3.0 you can embed the TLS key log file in a pcapng file. This makes it much easier to distribute capture files with decryption secrets, and makes switching between capture files easier since the TLS protocol preference does not have to be updated.

For example:

```
editcap --inject-secrets tls,keys.txt in.pcap out.pcapng
```

Cygwin on Windows

```
$ tshark -Tfields -e frame.time -c 3 -r tz.pcap
Jan 30, 2019 10:30:30.000227000 Eur
Jan 30, 2019 10:30:30.012122000 Eur
Jan 30, 2019 10:30:30.014504000 Eur
$ TZ= tshark -Tfields -e frame.time -c 3 -r tz.pcap
Jan 30, 2019 11:30:30.000227000 W. Europe Standard Time
Jan 30, 2019 11:30:30.012122000 W. Europe Standard Time
Jan 30, 2019 11:30:30.014504000 W. Europe Standard Time
```

Cause: running Windows native executable using 'unknown' TZ value, is not understood by localtime function → falls back to UTC

Fix: unset TZ variable: `alias tshark="TZ= tshark"`
or `TZ=UTC`

RX capture mechanism (simplified)