Writing a TCP analysis expert system

...because it‘s cool!

Jasper Bongertz

Airbus CyberSecurity

About me

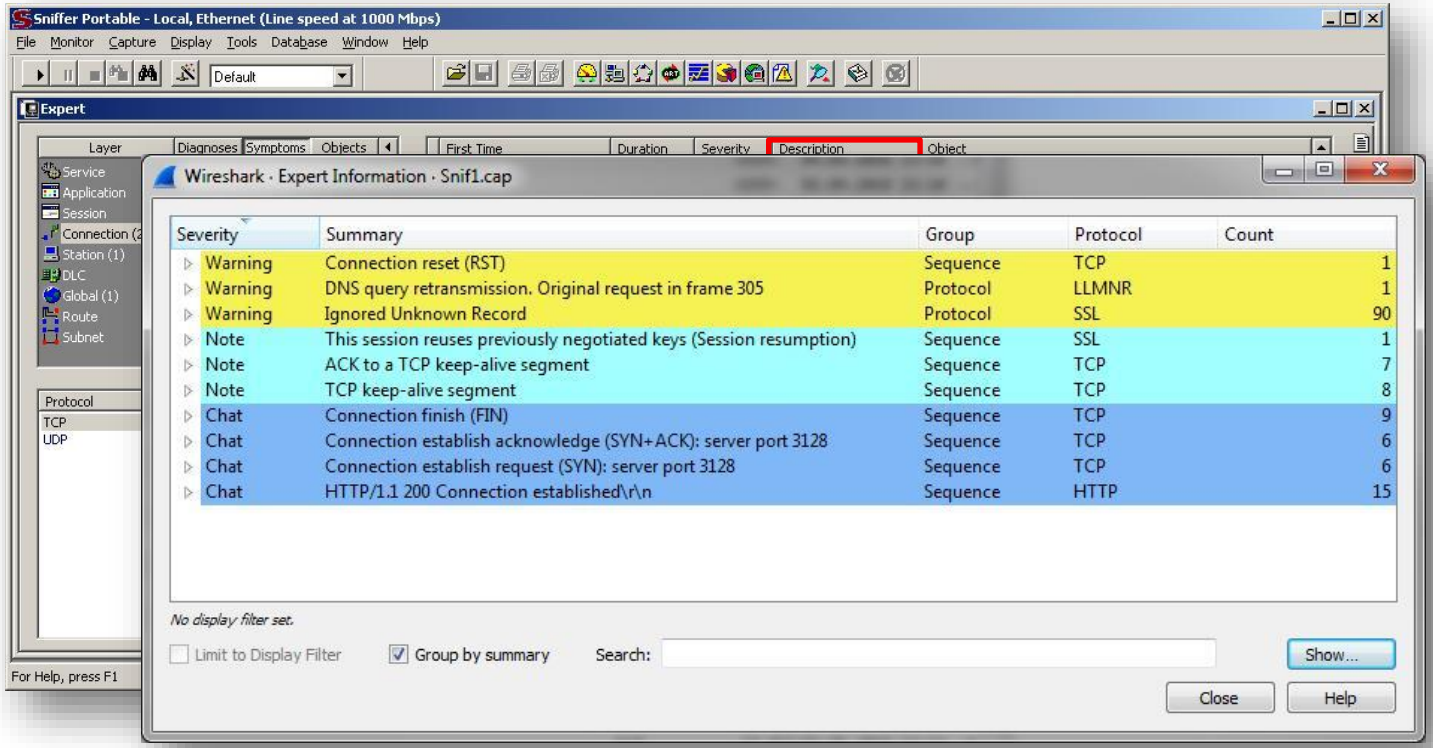
- Working at Airbus CyberSecurity
- Network analysis & forensics since 2003
  - NetXRay, Sniffer Pro/Distributed, Clearsight
  - Ethereal since... uh... version 0.9something
- Creator of
  - TraceWrangler
  - blog.packet-foo.com

TCP Expert Systems

TCP Expert Systems

- Analyse all available TCP packets
- Diagnose various relevant symptoms
- Help the analyst find problems

Relevant? Uhm...



Okay, some „POLA“

- POLA – Principle Of Least Anstonishment:
  - it means that something behaves as expected
- What we want from an expert system:
  - useful symptoms
  - not getting swamped
  - rated by criticality
  - provide recommended fixes, if at all possible

Let's analyze some TCP

- What's going on here?

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	192.168.122.69	192.168.101.111	TCP	62	2468 → 9887 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 SACK_PERM=1
2	0.011520	192.168.101.111	192.168.122.69	TCP	62	9887 → 2468 [SYN, ACK] Seq=0 Ack=1 Win=8192 Len=0 MSS=1349 SACK_PERM=1
3	0.011550	192.168.122.69	192.168.101.111	TCP	54	2468 → 9887 [RST] Seq=1 Win=0 Len=0
4	414.007506	192.168.122.69	192.168.101.111	TCP	62	[TCP Retransmission] 2468 → 9887 [SYN] Seq=0 Win=64240 Len=0 MSS=1349 SACK_PERM=1
5	414.007587	192.168.101.111	192.168.122.69	TCP	62	[TCP Retransmission] 9887 → 2468 [SYN, ACK] Seq=0 Ack=1 Win=8192 Len=0 MSS=1460 S

- And here?

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	172.18.0.122	172.18.50.1	TCP	74	51004 → 102 [SYN] Seq=0 Win=14600 [TCP CHECKSUM INCORRECT] Len=0 MSS=1460 SACK_PERM=1 TSval=147472368 TSecr=0 WS=128
2	0.002750	172.18.50.1	172.18.0.122	TCP	70	102 → 51004 [SYN, ACK] Seq=0 Ack=1 Win=5840 Len=0 MSS=1460 TSval=2874599 TSecr=1072693248
3	0.002834	172.18.0.122	172.18.50.1	TCP	54	51004 → 102 [RST] Seq=1 Win=0 Len=0
4	1.407994	172.18.0.122	172.18.50.1	TCP	74	51010 → 102 [SYN] Seq=0 Win=14600 [TCP CHECKSUM INCORRECT] Len=0 MSS=1460 SACK_PERM=1 TSval=147472720 TSecr=0 WS=128
5	1.410869	172.18.50.1	172.18.0.122	TCP	70	102 → 51010 [SYN, ACK] Seq=0 Ack=1 Win=5840 Len=0 MSS=1460 TSval=2874740 TSecr=1095761920

Sneak Peak

```
[d:\traces]tcpinvestigator.exe TCPSample01.pcapng

Investigating file "TCPSample01.pcapng"

Address A;Port A;Address B;PortB;Handshake State;Teardown Client;Teardown Server;Reset
State;Symptoms;State Location;Client IP;First IP seen;Client determined;Common
MSS;GapRatio;Total Symptom Score;Initial RTT (ns);SYN Packets Seen;SYN Reset count;Client FIN
count;Server FIN count;Client RST count;Server RST count;Client packet count;Server packet
count;Client discarded packets;Server discarded packets;Client CRC errors;Server CRC
errors;Client TTL;Server TTL;Client MSS;Server MSS;Display Filter;Capture Filter

192.168.0.102;49230;23.235.37.194;80;Complete;None;None;Server;tsRoutingDuplicate|tsSYNACKRetr
ansmit|tsPacketsAfterReset|tsMultiServerTTL;ClientLocal;192.168.0.102;192.168.0.102;true;1460;
63;46;11529000;1;0;0;0;0;2;3;6;2;0;3;0;128;60;1460;1460;ip.addr==192.168.0.102 and
ip.addr==23.235.37.194 and tcp.port==49230 and tcp.port==80;host 192.168.0.102 and
23.235.37.194 and tcp port 49230 and 80
```

Challenges

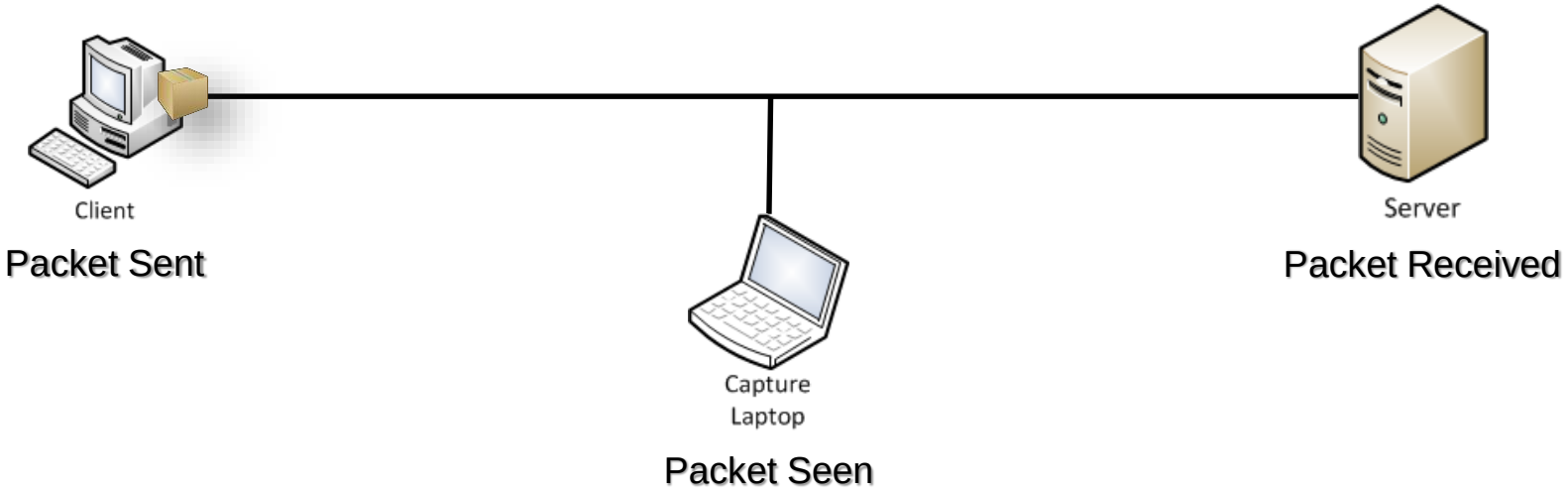
- TCP analysis is easy to learn, hard to master:
  - it requires experience, experience, experience
  - Example: „Hey, a RESET Packet! Is that bad?"
- Challenge: Programmers writing analysis software may not be TCP experts:
  - „I guess *ACK too long* is a useful symptom, right?"
  - BTW: nope. About the same as *Window Frozen* ☺

Challenges

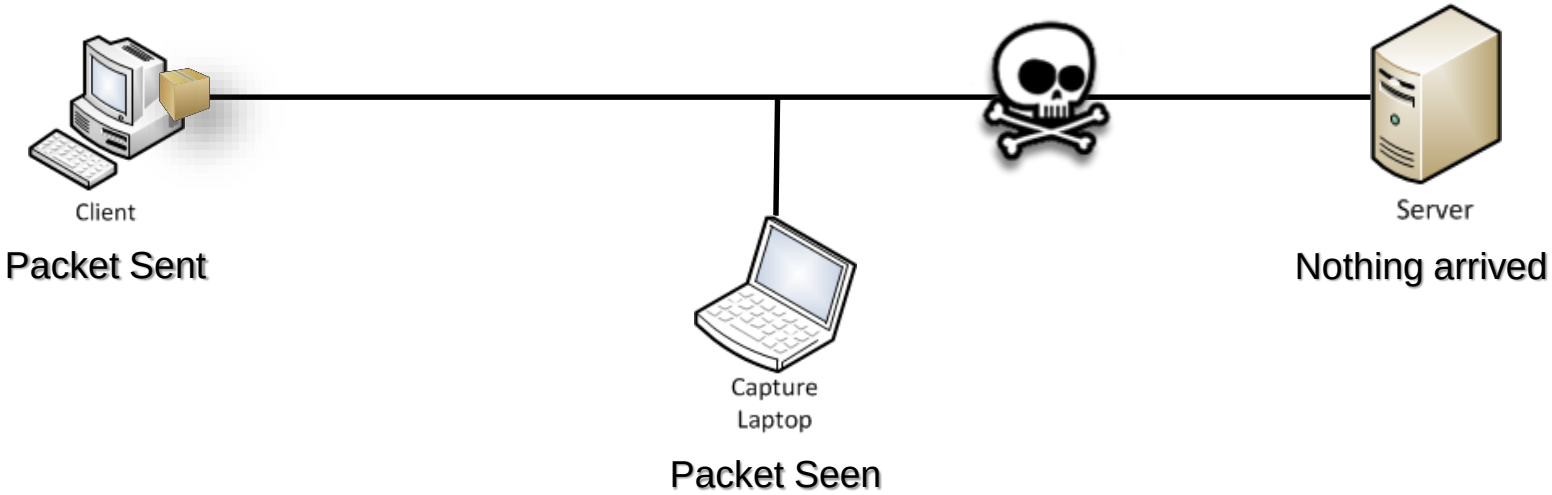
- There are three truths in TCP:
  - What the TCP client knows
  - What the TCP server knows
  - What the trace contains (notice: no „knows" here)
- Key factor: the capture location and setup:
  - timings, packet out-of-order situations
  - packet loss, duplicate frames

Attention – 4 Animations ahead!

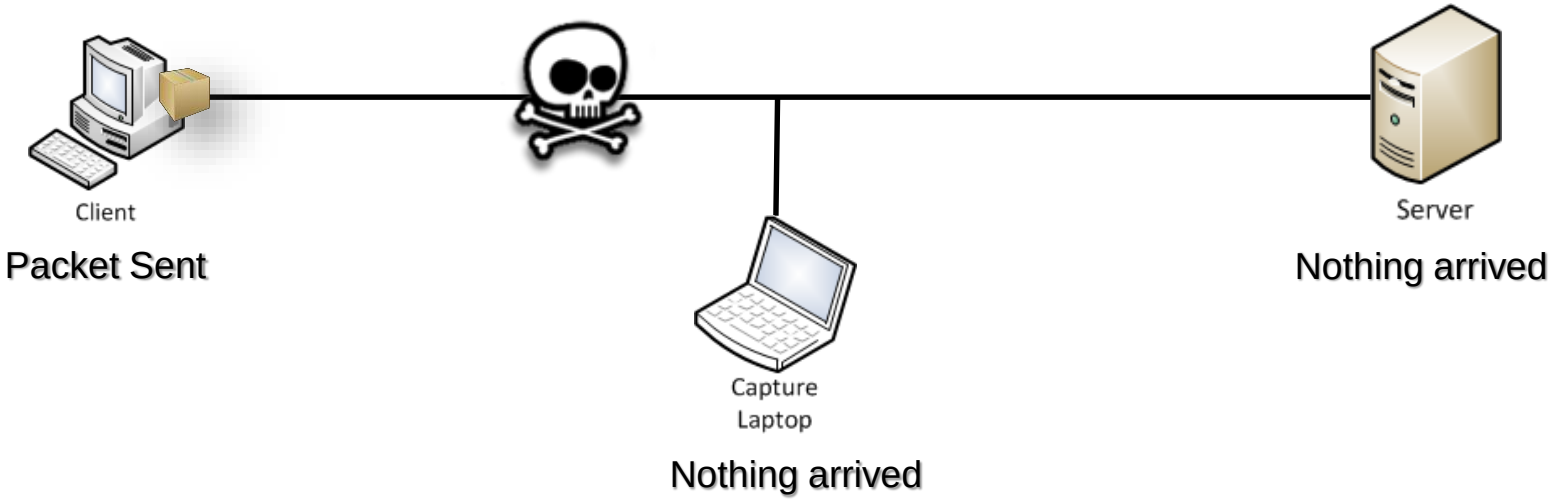
Three Truths Example #1



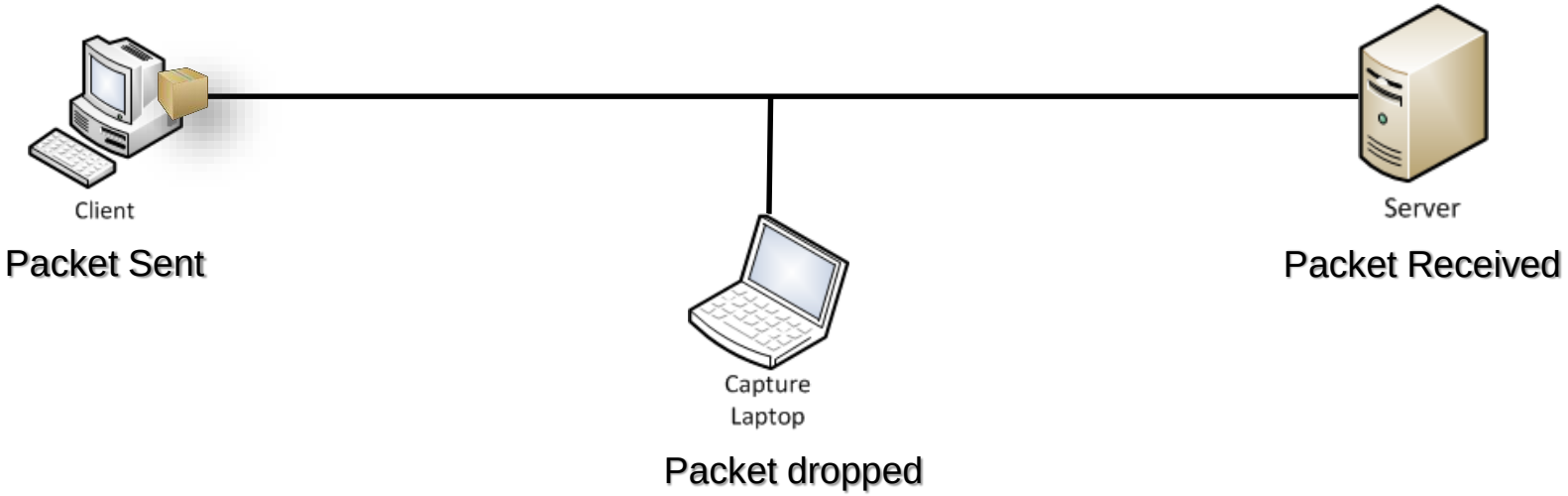
Three Truths Example #2



Three Truths Example #3



Three Truths Example #4



The 6-Tuple

Huh?! 6-Tuple???

- TCP analysis requires looking at a single conversation at a time
- Usually the 5-Tuple is enough:
  - Protocol (UDP/TCP)
  - Source IP, DestinationIP
  - Source Port, DestinationPort
- New: ISN (Initial Sequence Number)

TCP Handshake

TCP handshake

- Very important: the TCP handshake packets
  - TCP options
  - Who‘s who
  - Initial Rout Trip Time
- Challenge: determining handshake packets
- What if we don‘t have any? Or just some? Or they arrive out of order?

TCPInvestigator is a prototype

- Mostly focused on the handshake/teardown as of now
  - Investigating the full conversation flow still needs to be added
  - Has 102 different data points already
- A full rewrite may be necessary at a later stage
  - Nested case statements are not very elegant
  - Maybe going for a state machine instead

Code Example

```
// Check for sequence number wraps about to happen

if Parser.NextExpectedSequenceNumber.WrapCount = (Parser.SequenceNumber.WrapCount + 1) then
   State.Symptoms := State.Symptoms + [tstcpSequenceWrapped];

if (tcpSYN in Parser.Flags) then
   begin
        // Got a SYN or SYN/ACK in the new packet

        // TODO: may need to update TCPTuple ISN via UpdateISN

        case State.Handshake of
         hsNone          : begin
                                // we had packets, but neither SYN nor SYN/ACK yet. This is very uncommon ar

                                State.Symptoms := State.Symptoms + [tsHandshakeOutOfOrder];

                                if SourceIsClient then
                                   begin
                                        if Timestamp < State.LastClientTimestamp then
                                           State.Symptoms := State.Symptoms + [tsFrameOutOfOrder];
                                   end
                                else
                                    begin
                                        if Timestamp < State.LastServerTimestamp then
                                           State.Symptoms := State.Symptoms + [tsFrameOutOfOrder];
                                    end;
```

1 Pass? 2 Pass? 3 Pass?

- Examining TCP packets in a single pass may not enough
  - depends on capture file size and resources
  - E.g. „how long can you wait for a possible out-of-order/retransmission segment"?
- I expect at least 2 passes are required
  - e.g. also to deal with SACK edge blocks

Symptom detection

- Single packet
  - e.g. missing TCP options like MSS in the handshake
- Conversation packets
  - this is the majority, e.g. packet loss
- Global
  - e.g. pulling info from other conversations as baseline, like iRTT

Demos!!!11

Q&A

Mail: jasper@packet-foo.com
Web: blog.packet-foo.com
Twitter: @packetjay