DDoS Detection

How to know if you are attacked or partake in an attack

Klaus Möller
WP8-T1

Webinar, 15th of February 2021

Public

www.geant.org

What we will cover today

- Introduction to the detection task
- Sensors used in DDoS detection
  - Short Introduction to NetFlows
  - Example of a detection system: NeMo
- Detection
  - Workflow
  - Structured Traffic Analysis
- Traffic Details
  - Control Server, Bots, D(R)DoS
  - Backscatter

DFN DEUTSCHES FORSCHUNGSNETZ DFN CERT

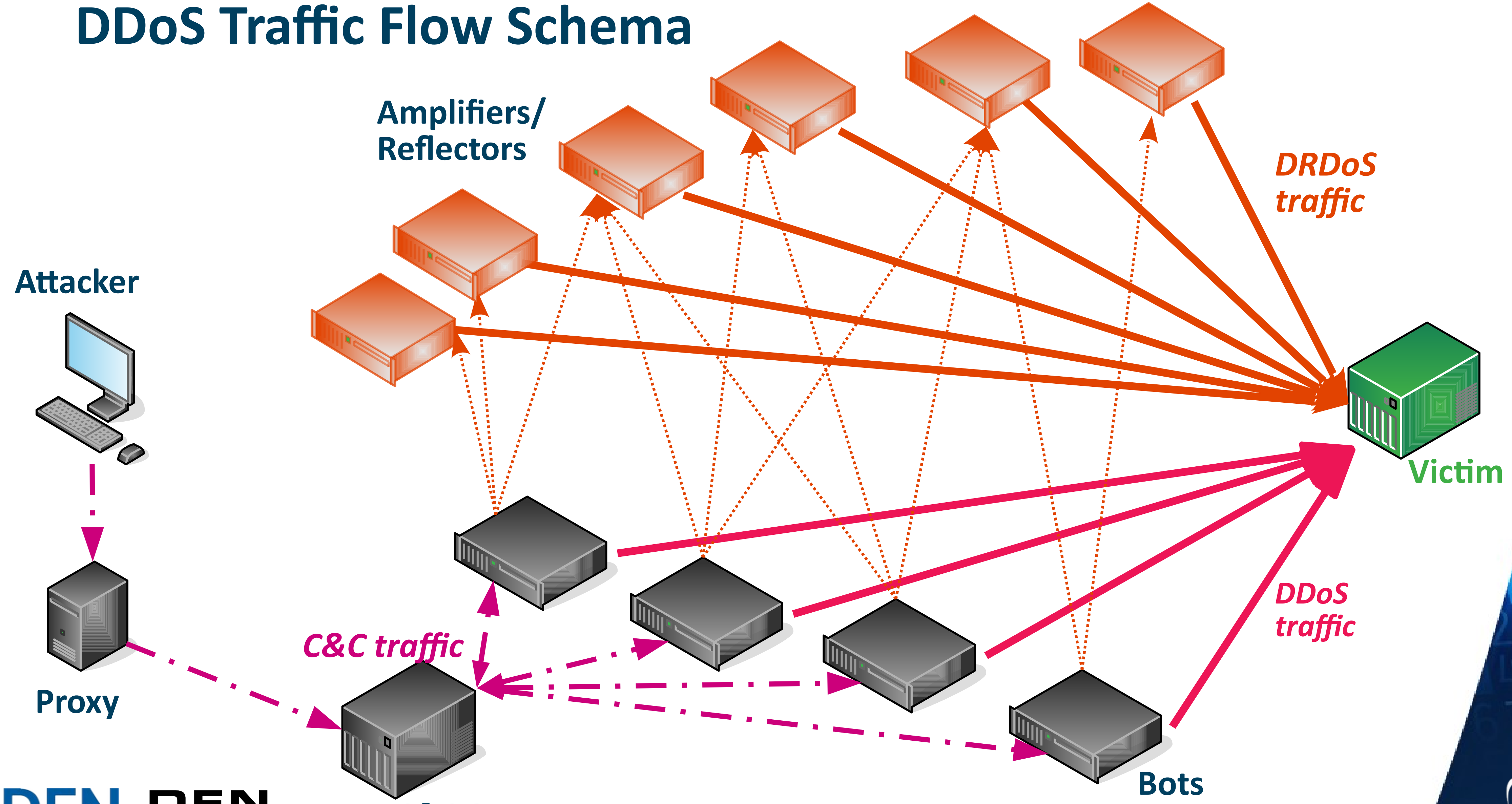
GÉANT

Introduction to Detection

www.geant.org

The research leading to these results has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 731122 (GN4-2).

DDoS Traffic Flow Schema



Challenges/Obstacles in DDoS Detection

- Sensor needs to be in path of the traffic type to be detected
- Distinguishing malicious traffic (C&C, D(R)Dos) from legitimate
  - Low false positive rate
- Reliable detection
  - Low false negative rate
- Timely
  - No use if too late
- Actionable
  - Results must allow mitigation or other useful action

Critical for acceptance and usability!

Sensors

www.geant.org

The research leading to these results has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 731122 (GN4-2).

Sensor Placement

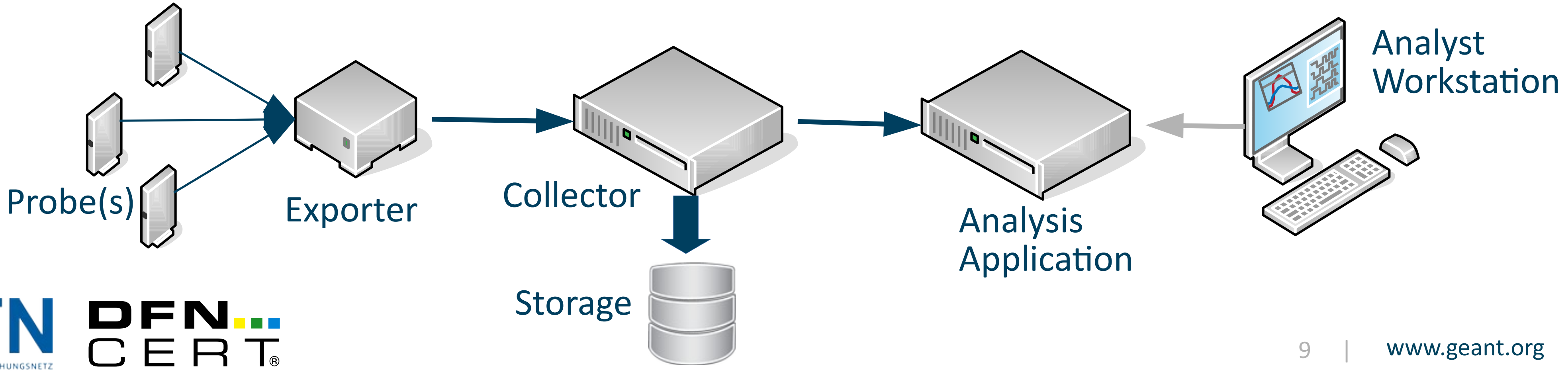
- ISP: Ingress/egress points into network
  - At least the most important ones (better all of them)
  - Alternatively: Core links/routers (fewer sensors needed)
- Victim network: Link(s) to ISP(s)
  - Sometimes only link to vital on-premise servers
- Placement dictated by available resources
  - Processing power, bandwidth, memory, or bus-slots in routers/switches
  - Rack space (mitigation needs a lot more)
  - Ultimately a question of available budget

Sensor Types

- **Packet sniffers** – tcpdump, wireshark, etc.
  - 1:1 copy of network packets, huge amounts of data
- **Flow data** – NetFlow, sFlow, Argus, AppFlow, NetStream, etc.
  - Reduced amount of data, but still usable for accounting and security purposes
- Various values read from system or SNMP MIB
  - CPU load, bandwidth used, error rates, queue usage, etc.
- Miscellaneous data
  - Routing tables
  - Customer Relationship Management (CRM): contacts, billing, etc.
  - Cabling, system location, hardware information, etc.

NetFlow

- Traffic is observed by ***probes*** at ***observation points*** *(IPFIX)*
  - Can be dedicated hardware probes, but often build into routers and switches
- Data from probes is aggregated by the ***exporter*** that sends flow records to a ***collector*** that stores the flow records data while the ***analysis application*** analyzes the traffic in the context of intrusion detection, traffic profiling, etc.
- Protocol for the data exchange between exporter and collector has been standardized as NetFlow (RFC 3954)
  - Later standard that builds on NetFlow: IP Flow Information Export (IPFIX, RFC 7011/12)
  - Storage format is **not** standardized (but conversion-tools exist)



(Net)Flow Records

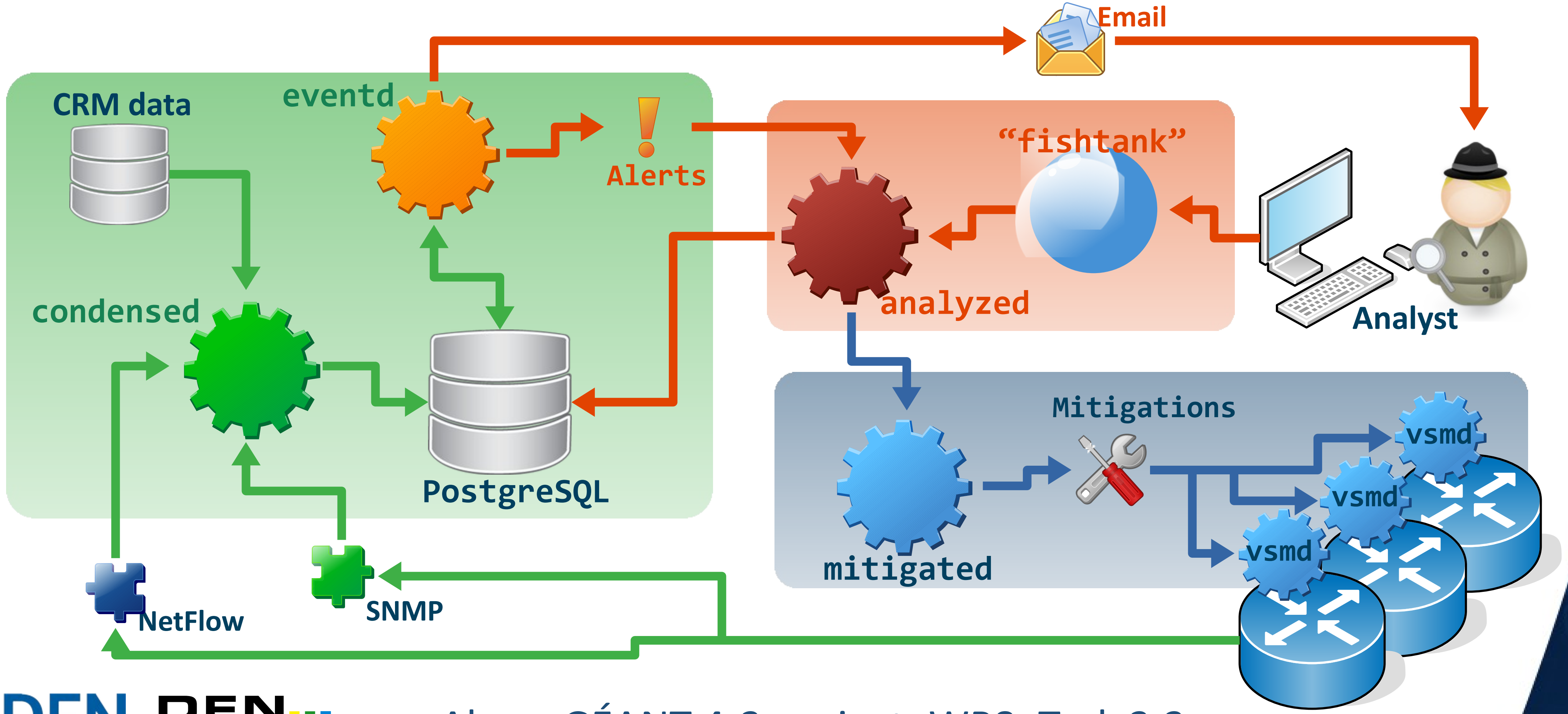
- Flow: *any number of packets observed in a specific time slot and sharing a number of properties*
  - Source & destination IP address
  - IP protocol number (e. g. ICMP, TCP, UDP, etc.)
  - TCP/UDP/SCTP source & destination port numbers, or ICMP type & code
  - IP Type of Service (TOS)
  - By definition: Flows are unidirectional
  - Application data (layer 5+) not part of the flow data
- Flow record: the above information plus
  - Number of packets & bytes seen in the timeslot
  - More data: input/output interface, AS number, next hop address and more
    - Depending on the NetFlow protocol version used

Sampled NetFlow

- Evaluating every packet consumes too many resources on high-speed links
  - Sampling reduces number of packets taken into account: 1 out of n
  - n: Sample Rate (typically 100 - 1.000.000)
  - Result is called ***Sampled NetFlow***
  - Still accurate enough for a general traffic picture and DDoS detection
  - More privacy protection friendly (except for n = 1:)
  - Might not detect small, short-lived flows at larger values of n
- Do not confuse with ***sFlow*** (Sampled Flow, RFC 3176)
  - Samples of counters
  - (Random) samples of packets or ***application operations***

NeMo - Network Monitoring

System to detect and mitigate DDoS attacks in the German NREN (DFN)

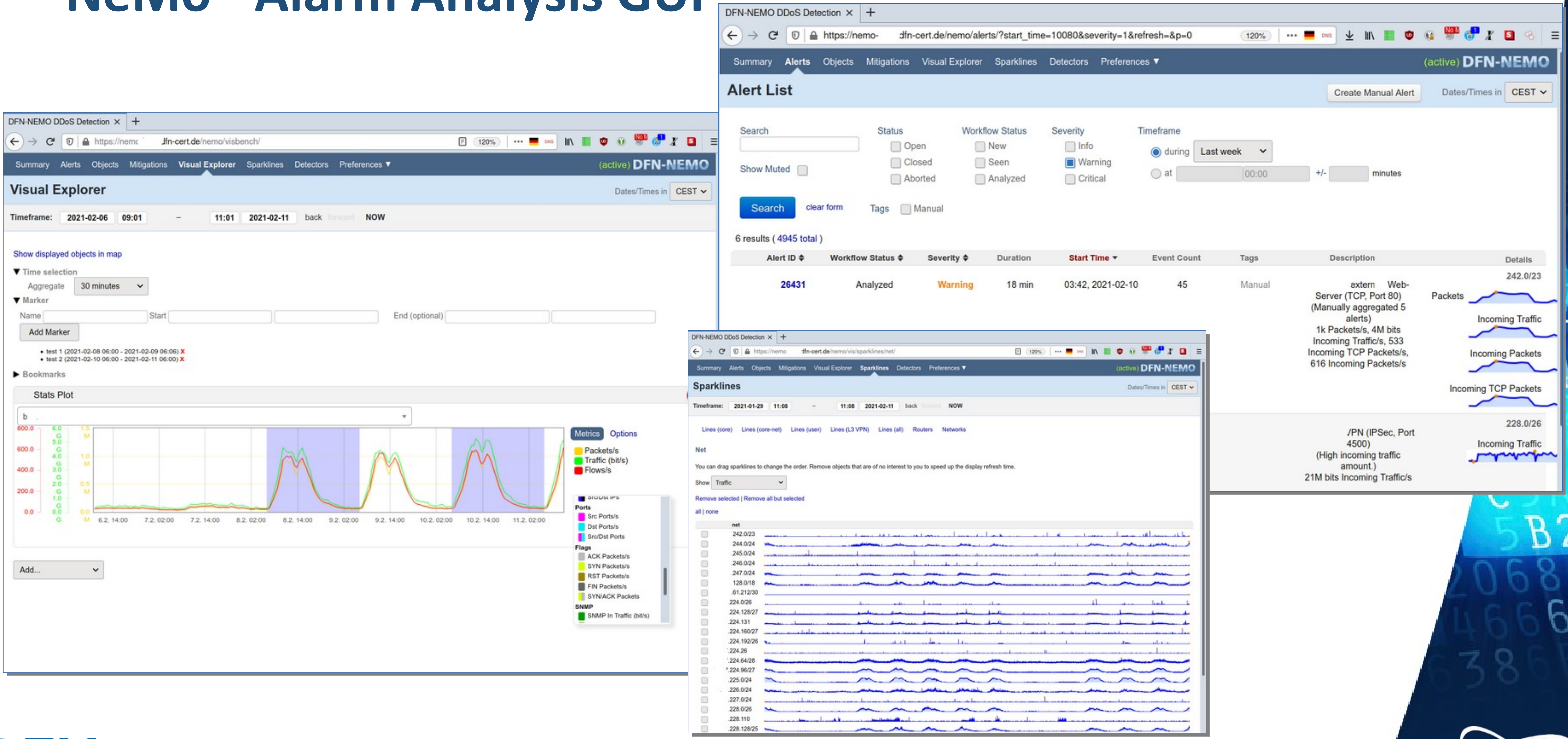


DFN DFN-CERT

Also a GÉANT 4-3 project: WP8, Task 3.3

www.geant.org GÉANT

NeMo - Alarm Analysis GUI



Detection

www.geant.org

The research leading to these results has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 731122 (GN4-2).

Detection Workflow – Base lining

- If you don't know what's normally going on in your network
  - How will you ever know when something unusual happens?
  - When things stop working/people complain?
  - It's too late to start base lining then
- Even when outsourcing or automating (AI), an overview is needed
  - How else will you know if you're being ripped of or what the AI is learning?
- Know your network, esp. traffic distribution
  - Most active source and destination IP addresses ("top talkers")
  - Network link utilization
  - Transport & application distribution
  - Traffic changes over time – trends, recurrences (work hrs, holidays, …)

Structured Traffic Analysis 1/4: Statistics

- Protocol hierarchy breakdown
  - IPv4/IPv6, TCP, UDP, HTTP, SSH, DNS, etc.
  - Gives a first idea with what to deal (e. g. ICMP flood, UDP flood) and which service (port number) is being attacked

Protokoll	Prozentualer Anteil bei den Paketen	Pakete	Prozentualer Anteil der I
Frame	100.0	3510	63.8
Ethernet	100.0	3510	9.3
Internet Protocol Version 4	100.0	3510	
User Datagram Protocol	100.0	3510	
Internet Security Associati...	2.3	81	
Short Frame	2.3	81	
Data	97.7	3429	

Ethernet · 4 | IPv4 · 27 | IPv6 | TCP | UDP · 35

Address	Port	Packets	Bytes	Tx Packets
85.14.245.77	64738	3.429	468k	2.27
.178.82	56063	427	57k	15
119.155	61026	400	54k	13
.119.155	54009	358	49k	12
165.85	57092	342	46k	9
240.215	54617	332	44k	11
.164.120	53268	330	45k	9

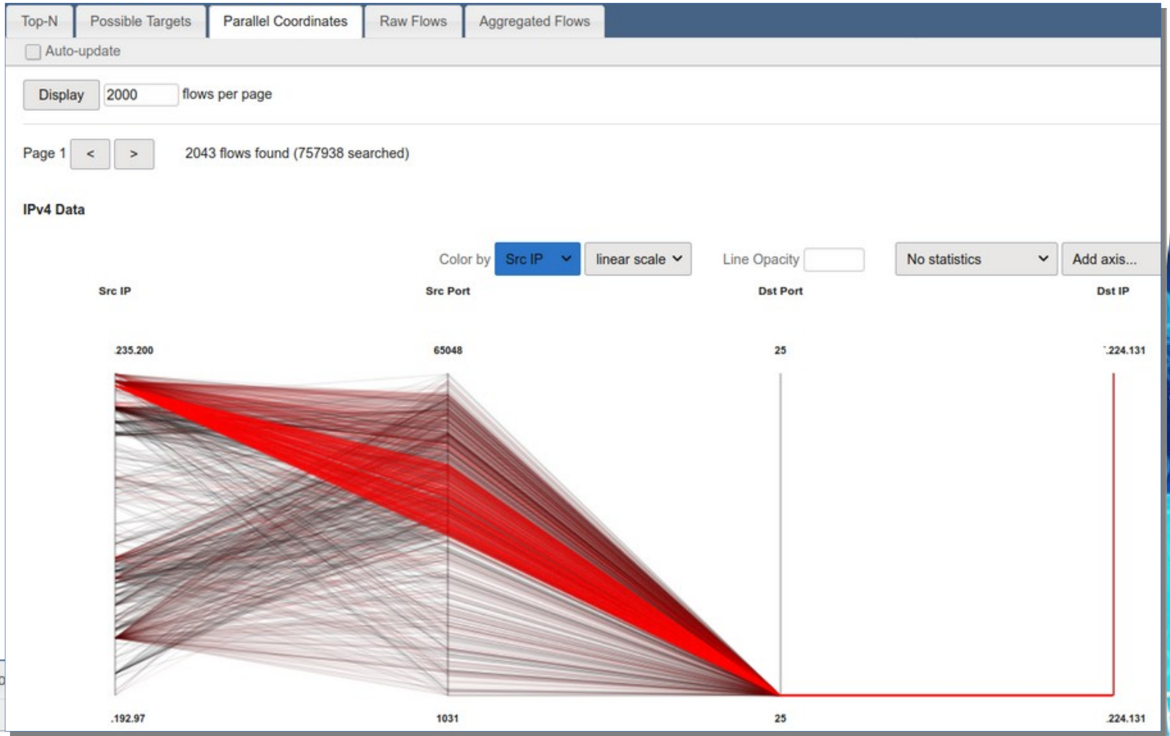
Structured Traffic Analysis 2/4: Size(s) matter

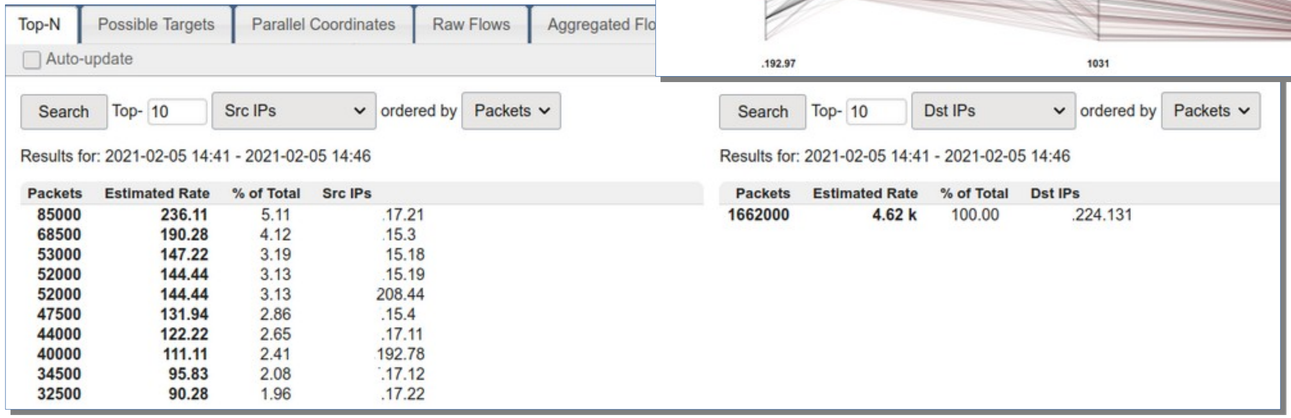
- Packet size distribution
  - Many small packets → possible sign of packet switching attack
  - Many large packets → possible sign of bandwidth exhaustion attack

Topic / Item	Count	Average	Min Val	Max Val	Rate (ms)	Percent	Burst Rate	Burst Start
Packet Lengths	3510	150,49	99	737	0,0000	100%	0,0200	1277,692
0-19	0	-	-	-	0,0000	0,00%	-	-
20-39	0	-	-	-	0,0000	0,00%	-	-
40-79	0	-	-	-	0,0000	0,00%	-	-
80-159	3429	136,64	99	152	0,0000	97,69%	0,0200	1277,692
160-319	0	-	-	-	0,0000	0,00%	-	-
320-639	0	-	-	-	0,0000	0,00%	-	-
640-1279	81	737,00	737	737	0,0000	2,31%	0,0100	223128,846
1280-2559	0	-	-	-	0,0000	0,00%	-	-
2560-5119	0	-	-	-	0,0000	0,00%	-	-
5120 and greater	0	-	-	-	0,0000	0,00%	-	-

Structured Traffic Analysis 3/4 : Sessions (Flows)

- Look for sessions (flows)
  - Incoming vs. outgoing traffic
  - Top talkers (IP addresses)
- Known Good/Bad IP addresses
  - Partners/Customers
  - WoT, Shadowserver, MISP, etc.





DFN DEUTSCHES FORSCHUNGSNETZ DFN CERT

GÉANT

Structured Traffic Analysis 4/4 : Full packet captures

- Sometimes needed
  - Easy to get with sFlow
  - Or via port mirroring of switches or dedicated probes at critical points
  - But need to set up sensors in advance
- Gives insight into
  - Application type of attacks
- Check samples against NIDS to look for exploits of vulnerabilities
  - Zeek (Bro), Suricata, Snort, Yara, etc.
- Don’t forget decryption for TLS or VPNs
- Check with your DPO (esp. with little/shaky evidence)

Traffic Characteristics

www.geant.org

The research leading to these results has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 731122 (GN4-2).

DDoS Traffic Characteristics: C&C Server

- From Attacker (via Proxy) to C&C Server
  - Traffic type may vary: HTTPS, VPN, or other
- From Bots to C&C server (cmd pull) or
  - Short lived connections (usually just one HTTP GET request)
  - Small amount of data transferred (bot cmd, bot config, sometimes code updates)
  - Server IP address may co-host legitimate websites
- From C&C server to Bots (cmd push)
  - Will need open port on the Bot
    - Traffic may be piggybacked on top of other traffic (HTTP, DNS, etc.)
  - Or reverse connection
    - Usually long-lived
- Bottom line: too hard, don't bother, unless you have a lead to follow

DDoS Traffic Characteristics: Bots vs. Clients

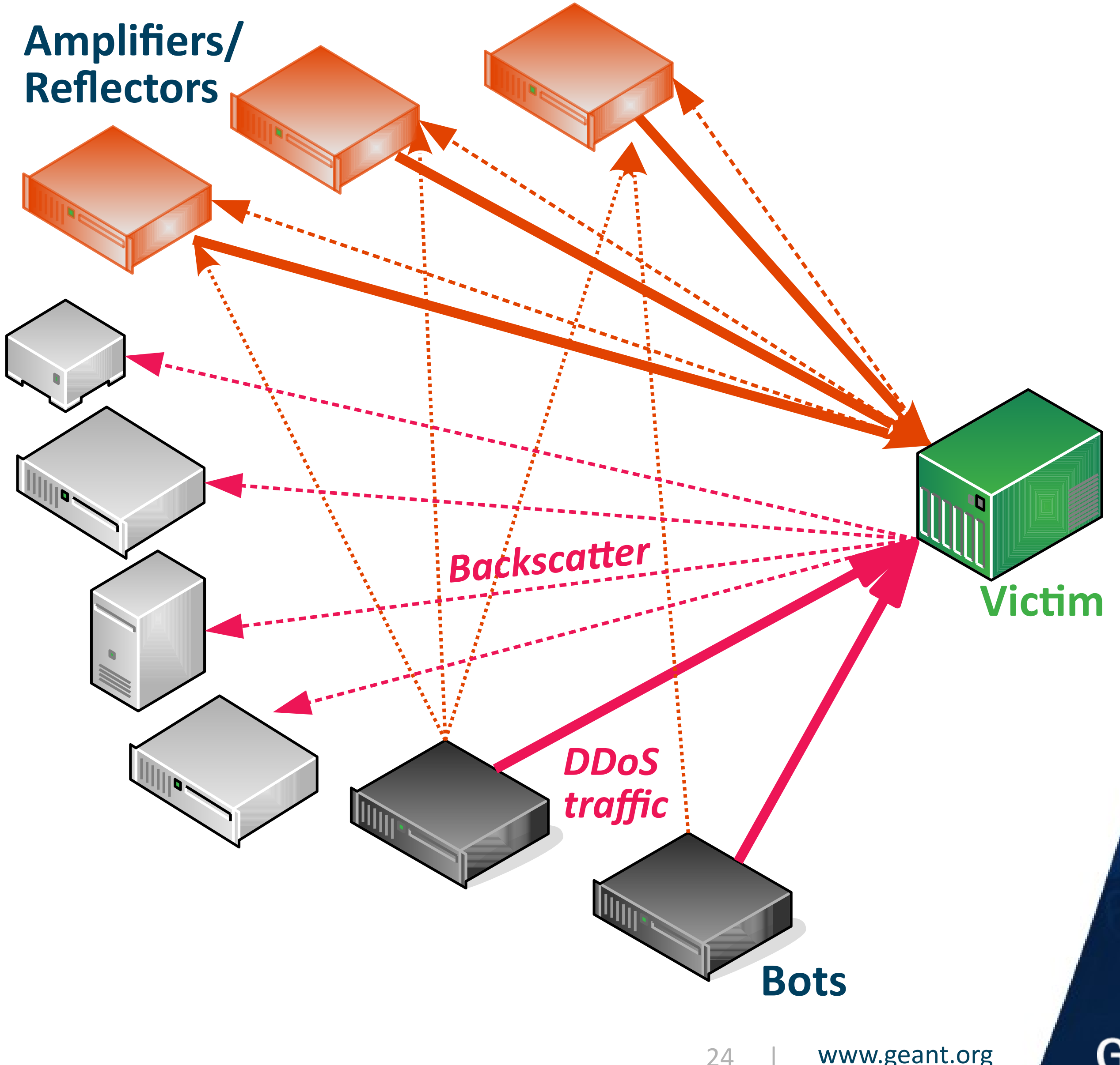
- Bots to Victim traffic
  - Source IP address: Spoofed (random)
    - When source addresses are filtered: subnet of the bot or the bot itself
  - Lots of “empty” sessions:
    - Low number of packets,
    - Very little data transferred, small packets (unless flooding)
- Normal (high usage) traffic
  - Lower number of source IP-addresses
    - Often known, like backup servers, customers, partners, etc.
  - Sessions do actually transfer data - more symmetric traffic distribution
  - Is there a reason?
    - Backup time, *“slashdotted/heise effect”*, launch of service, …?

DDoS Traffic Characteristics: DRDoS Traffic

- Protocols:
  - Usually ICMP or UDP - easy spoofing
  - Rarely TCP - needs application that can be triggered
- From Amplifiers/Reflectors to victim
  - Source address of amplifier is not spoofed
  - Often that of known open amplifiers (→ Shadowserver)
- From Bots to Amplifiers/Reflector
  - Bandwidth used usually not suspicious
    - Small packets
    - Bot distributes traffic across many amplifiers/reflectors
    - Unless sensor is placed in front of the reflector

DDoS Backscatter

- DDoS traffic may elicit responses from victim
  - I.e. TCP SYN-ACK packets in response to TCP SYN (floods)
  - Or ICMP unreachable, or
  - Application responses, ...
- To random IP addresses if bots spoof the source IP address
  - If not spoofed, directly back to the bots IP address
  - Responses to DRDoS traffic will go to back amplifiers/reflectors



DDoS Backscatter Detection - *Network Telescope*

- Technology used is the same as for other DDoS traffic
  - Sensors, collectors, analysers, etc.
- To distinguish from other traffic, look only for incoming traffic to unused (dark) IP addresses
  - ***"Darknet"***, if interspersed with live addresses → ***"Greynet"***
  - Other names: ***"network motion sensors", "network sink", "blackhole monitor"***
  - Best if IP address space was never used in production (very rare today)
  - Doesn't need to be continuous
  - Amount of DDoS traffic seen by sensors would be proportional to the number of IP addresses covered by sensors
  - Assuming perfectly random distribution with spoofed IP addresses

DDoS Backscatter Detection - Traffic Patterns

- Source IP address is that of the victim
- Random destination IP addresses, no coherence
- Source port that of the attacked service
  - Usually port 80/tcp or 443/tcp
- Destination ports random, usually ephemeral ports (> 1023)
  - May see some "ladder" if DDoS tool uses changing port numbers
- Layer 5+ contents depend on type of DDoS
  - Will not be present in flow data - full packet captures needed
- Traffic may be from multiple DDoS techniques as attackers employ them at once against a target

Detection Systems

www.geant.org

The research leading to these results has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 731122 (GN4-2).

What have you learned?

- Analysis looks easy
  - Have some nice tools
  - Structured approach
  - I can do that:)
- Not to stall optimism, **BUT**
  - Examples shown are labs/low usage networks
  - Analysis on busy production networks is much harder
  - Most of today's DDoS attacks are using more than one vector
  - Attackers adapt to countermeasures → i.e. change tactics & techniques
- Practice, practice, practice, …
- And then you need to mitigate the attack → next session

DFN DEUTSCHES FORSCHUNGSNETZ DFN CERT®

GÉANT

Thank you

Any questions?

Next course: ***DDoS Mitigation***

17th of February 2021

www.geant.org

The research leading to these results has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 731122 (GN4-2).

References:

- M. Collins: *“Network Security Through Data Analysis – Building Situational Awareness”*, O’Reilly, February 2014: ISBN:978-1-449-35790-0
- M. Collins: *“Network Security Through Data Analysis – From Data to Action”*, 2nd Ed. , O’Reilly, October 2017, ISBN: 978-1491962848
- R. Bejtlich: *“Tao of Network Security Monitoring, The: Beyond Intrusion Detection”*, Addison Wesley, July 2004, ISBN-13: 978-0321246776
- R. Bejtlich: *“The Practice of Network Security Monitoring: Understanding Incident Detection and Response”*, NoStarch Press, July 2013, ISBN-13: 978-1593275099
- M. W. Lucas: “Network Flow Analysis”, NoStarch Press, 2010, ISBN-13: 978-1-59327-203-6
- Joseph O’Hara: *“Cloud-based network telescope for Internet background radiation collection”*, University of Dublin, Trinity College, April 2019, `https://scss.tcd.ie/publications/theses/diss/2019/TCD-SCSS-DISSERTATION-2019-020.pdf`
- Shadowserver Foundation: `https://www.shadowserver.org/`

NetFlow Tools

- Pmacct: https://github.com/pmacct/pmacct/
- *NFStream*: https://www.nfstream.org/
- *argus:* https://www.qosient.com/argus/downloads.shtml
- *Softflowd:* https://github.com/irino/softflowd
- *SLiK Suite:*
  - *FlowViewer GUI for SILK tools:*
- *Nfdump:* https://github.com/phaag/nfdump
- *Nfsen-ng:* https://github.com/mbolli/nfsen-ng
- *GoFlow:* https://github.com/cloudflare/goflow
  - https://github.com/cloudflare/flow-pipeline
- *Dynamite NSM:* https://dynamite.ai/dynamitensm/
  - https://github.com/DynamiteAI/dynamite-nsm
- *Security Onion:* https://securityonionsolutions.com/

RFCs

- P. Phaal, RFC 3176: "InMon Corporation's sFlow: A Method for Monitoring Traffic in Switched and Routed Networks ", September 2001, `https://tools.ietf.org/html/rfc3176`
- B. Claise, Ed., RFC 3954: "Cisco Systems NetFlow Services Export Version 9", October 2004, `https://tools.ietf.org/html/rfc3954`
- B. Claise, Ed., RFC 7011: "Specification of the IP Flow Information Export (IPFIX) Protocol for the Exchange of Flow Information", September 2013, `https://tools.ietf.org/html/rfc7011`
- B. Claise, Ed., RFC 7012: "Information Model for IP Flow Information Export (IPFIX)", September 2013, `https://tools.ietf.org/html/rfc7012`