Wanguard 8.0 User Guide

- Console
- Packet Sensor, Flow Sensor, SNMP Sensor, Sensor Cluster
- Packet Filter, Flow Filter, Filter Cluster

Revision 8.16

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Notices

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Traffic Monitoring and DDoS Mitigation with Wanguard

Andrisoft Wanguard is an award-winning enterprise-grade software solution designed to monitor and protect large WAN networks against volumetric DDoS attacks.

Unforeseen traffic patterns affect user satisfaction and clog costly transit links. Providing reliable network services is imperative for the success of today's organizations. As the business cost of network malfunctions continues to increase, rapid identification and mitigation of threats to network performance and reliability become critical in order to meet expected SLAs and network availability requirements. Such threats include distributed denial-of-service attacks (spoofed SYN flood, NTP amplification attacks, generic UDP floods, etc.), propagating worms, misuse of services, and interference of best-effort traffic with critical or real-time traffic. Wanguard's network-wide surveillance of complex, multilayer, switched or routed environments together with its unique combination of features is specifically designed to meet the challenge of pinpointing and resolving any such threats.

Key Features & Benefits

- ✔ **FULL NETWORK VISIBILITY** – Supports all major IP traffic monitoring technologies: packet sniffing, NetFlow version 5, 7 and 9; sFlow version 4 and 5; IPFIX and SNMP
- ✔ **COMPREHENSIVE DDOS DETECTION** – Leverages an innovative traffic anomaly detection engine that quickly detects volumetric attacks by profiling the online behavior of users and by comparing over 130 live traffic parameters against user-defined thresholds
- ✔ **ON-PREMISE DDOS MITIGATION** – Protects networks by using BGP blackhole routing or Flowspec; protects services by cleaning malicious traffic using packet-scrubbing servers deployed in-line or out-of-line
- ✔ **FAST, SCALABLE & ROBUST** – Designed to run on commodity server hardware by leveraging high-speed packet capturing technologies such as DPDK, PF_RING Vanilla, PF_RING ZC and Netmap. Can run as a cluster with its software components distributed across multiple servers
- ✔ **POWERFUL REACTION TOOLS** – Executes predefined actions which automate the reaction to attacks: sends notification emails, announces prefixes in BGP, generates SNMP traps, modifies ACLs, and runs scripts that have access to hundreds of internal parameters via an easy-to-use API
- ✔ **DETAILED FORENSICS** – Captures samples of packets and saves flows for the forensic investigation of each attack. Detailed attack reports can be emailed to you, affected customer or the attacker's ISP
- ✔ **ENTERPRISE-GRADE WEB CONSOLE** – Provides consolidated management and reporting through a highly-configurable multi-tenant web portal with customizable dashboards, user roles, and remote authentication
- ✔ **PACKET SNIFFER** – Saves packet dumps using a distributed packet sniffer that can be deployed on different network entry points. Displays packet details in a Wireshark-like web interface
- ✔ **FLOW COLLECTOR** – Contains a fully-featured NetFlow, sFlow, and IPFIX collector that saves flow data in a compressed format for long term storage. Flows can easily be searched, filtered, sorted, and exported
- ✔ **COMPLEX ANALYTICS** – Generates complex reports with aggregated data for hosts, departments, interfaces, applications, ports, protocols, countries, autonomous systems, and more
- ✔ **REAL-TIME REPORTING** – Bandwidth graphs are animated and have a short-term accuracy of just 5 seconds
- ✔ **HISTORICAL REPORTING** – You can view reports from the last 5 seconds to the last 10 years by selecting any

custom time period. Bandwidth histograms contain 95th-percentile values for burstable billing

- ✔ **SCHEDULED REPORTING** – Generates PDF and HTML reports and sends them automatically by email to the interested parties at preconfigured intervals of time
- ✔ **COMPLETE REST API** – All configurations and collected data can be easily queried and referenced via a fully-featured RESTful API which exposes hundreds of internal parameters, anomaly data, graphs and tops
- ✔ **THE LOWEST TCO** – It is the most affordable on-premise DDoS detection and mitigation software solution on the market

All configurations are stored in an SQL database that is easy to query, backup and restore.

Software Components

Wanguard Sensor provides traffic anomaly detection, bandwidth monitoring and traffic accounting. The collected information allows you to generate complex traffic reports, graphs, and tops; instantly pin down the cause of network incidents; automate the reaction to attacks; understand patterns in application performance and make the right capacity planning decisions.

Wanguard Filter is an optional component used for generating filtering rules that isolate the malicious traffic received by the attacked destinations. It can scrub off abnormal traffic in a granular manner without impacting the user experience or resulting in downtime.

Wanguard Console is a multi-tenant web graphical user interface that functions as the administrative core of the software. It offers single-point management and reporting by consolidating the data from all Wanguard Sensors, Wansight Sensors and Wanguard Filters deployed within the network.

For the sake of brevity, Wanguard Sensor is hereby referred to as the Sensor, Wanguard Filter as the Filter, and Wanguard Console as the Console.

Choosing a Method of Traffic Monitoring and DDoS Detection

This chapter describes the traffic monitoring technologies supported by Wanguard Sensor. There are four Wanguard Sensor “flavors”, each having a different way of obtaining traffic information:

- **Packet Sensor** analyzes packets. It can be used on appliances that are either deployed in-line (servers, firewalls, routers, bridges, IDSes, load-balancers) or connected to a mirrored port or TAP.

  In switched networks, only the packets for a specific device reach the device's network card. If the server running a Packet Sensor is not deployed in-line, in the main data path, then a network TAP or a switch or router that offers a “monitoring port” or “mirroring port” must be used. In this case, the network device sends copies of data packets traveling through selected ports or VLANs to the monitoring port. Packet Sensor inspects every packet it receives and conducts packet-based traffic analysis

- **Flow Sensor** analyzes flows. It is used for monitoring NetFlow® (jFlow, NetStream, cflowd), sFlow® and IPFIX flow packets.

  Many routers and switches can collect IP traffic statistics and periodically send them as flow records to a Flow Sensor. Because the flow protocol already performs pre-aggregation of traffic data, the flow data sent to Flow Sensor is much smaller than the monitored traffic, and this makes Flow Sensor a good option for monitoring remote or high-traffic networks. The main downside of flow-based traffic analysis is that pre-aggregating traffic data adds a delay of at least 30 seconds to collecting real-time traffic statistics

- **SNMP Sensor** monitors the bandwidth usage of routers and switches on a port-by-port basis.

  When this technology is used, an SNMP Sensor queries the device (e.g. router, switch, server) for the traffic counters of each port with small data packets. These are triggering reply packets from the device. Compared to other bandwidth monitoring technologies, the SNMP option is very basic and offers no IP-specific information. SNMP creates the least CPU and network load

- **Sensor Cluster** aggregates pre-existing Sensor traffic data into a single, unified anomaly detection and/or IP graphing domain.

  Sensor Cluster sums up the traffic data collected by Packet Sensors, Flow Sensor and SNMP Sensor interfaces and performs the same tasks as the other Sensors (IP graphing, IP accounting, anomaly detection, etc.)

For redundancy, high availability and to be able to view packet dumps and flow data, you can deploy Flow Sensor(s) and Packet Sensor(s) simultaneously.

Comparison between Packet Sniffing, Flow Monitoring and SNMP Polling

Packet Sensor is recommended when the speed of detecting attacks is critical, or when there is a need for capturing raw packets for forensics and troubleshooting. Because every packet entering the network is inspected, Packet Sensor needs to run on servers with powerful CPUs.

Flow Sensor analyzes pre-aggregated traffic information sent by routers and switches, so it can monitor traffic passing through multiple 10/40/100 GbE interfaces even when it runs on a low-end server. By comparison, Flow Sensor has some disadvantages:

- ✗ It exhibits reduced speed in processing real-time traffic information. Flow exporters aggregate traffic data over time, making the traffic visible only after a delay (flow aging) that usually exceeds 30 seconds
- ✗ It provides slightly less accurate traffic readings because in most cases the packets or flows are sampled
- ✗ Enabling the flow exporter functionality may result in an increased CPU load on the network device when the flow collection is not performed in hardware
- ✗ Flows can be dropped if a powerful spoofed DDoS attack fills the TCAM of the network device

SNMP Sensor is useful to monitor devices that cannot export flows or mirror packets, or to compare flow and SNMP-derived statistics in order to ensure the flow data's accuracy.

	Packet Sensor	Flow Sensor	SNMP Sensor
Traffic Monitoring Technology	• Sniffing packets passing an in-line appliance • Port mirroring (SPAN, Roving Analysis Port) • Network TAP	• NetFlow version 5, 7 and 9 (jFlow, NetStream, cflowd) • sFlow version 4 and 5 • IPFIX	• SNMP version 1 • SNMP version 2c • SNMP version 3
Maximum Traffic Capacity per Sensor*	100 GigE	multiples of 100 Gbps	multiples of 100 Gbps
DDoS Detection Time**	≤ 1 seconds	≥ flow aging time (≥ 30 seconds usually) + 5 seconds	≥ 5 seconds
IP Graph Granularity	≥ 5 seconds	≥ 20 seconds	N/A ((SNMP offers no details about IPs)
Traffic Validation Options	IP classes, MAC addresses, VLANs, BPF	IP classes, Interfaces, AS Numbers, Ingress/Egress	Interfaces
Packet Dumps	Yes	No	No
Flow Collector	No	Yes	No

* The number of connections between IPs is not a limiting factor
** Wanguard Sensor detects the IPs under attack. Wanguard Filter detects the sources of each attack

Choosing a Method of DDoS Mitigation

Wanguard provides a complete network-level protection against volumetric Denial of Service attacks by using several complementary methods:

- **Wanguard Sensor** can be configured to send announcements to your upstream providers to stop routing traffic towards the attacked destinations. This is a simple and widely-used DDoS protection technique that requires only a preexistent agreement with your BGP peers. The attacked targets will be blocked from accessing the Internet, avoiding the congestion of upstream and downstream links
- **Wanguard Filter** can be configured to clean the malicious traffic at the network's border, protecting critical services against attacks that are not congesting the upstream links. Dedicated filtering servers can be clustered in packet scrubbing farms
- **Wanguard Filter** can detect and apply filtering rules on third-party DDoS mitigation appliances, firewalls, load-balancers or routers via helper scripts or BGP Flowspec
- **Wanguard Filter** can be configured to send automatic notification emails to the ISPs originating attacks
- **Wanguard Sensor** can be configured to trigger an Internet Service Provider (ISP) or Managed Security Service Provider (MMSP) which offers cloud-based anti-DDoS services to start scrubbing the malicious traffic

DDoS Mitigation with Wanguard Filter

When Wanguard Sensor detects that a destination is under attack, it executes a preconfigured Response that can activate a Wanguard Filter instance. Filter instances cannot run stand-alone and can only be started via Responses.

Wanguard Filter includes a sophisticated traffic analysis engine that detects **attack patterns** heuristically, by inspecting the packets/flows sent to the attacked destinations.

Each attack pattern is formed by malicious packets that share some common OSI Layer 3-7 data:

- When an attack is launched from a non-spoofed IP address, the attack pattern is always the IP of the attacker
- When the attack is spoofed and comes from random IP addresses, the attack pattern can be a common source or destination TCP or UDP port, source or destination IP address, IP protocol number, packet length, packet content, TTL, ICMP type, DNS Transaction ID, originating country, and so on
- When Wanguard Filter detects multiple attack patterns, it generates only the filtering rule(s) that have the least negative impact on regular customer traffic

Each attack pattern detected by Wanguard Filter is translated into a **filtering rule** that can be applied on the server's NetFilter stateless firewall, on the network adapter's hardware packet filter, or on a third-party appliance or router. Wanguard Filter is designed to generate filtering rules that block the malicious traffic in a granular manner, without impacting the user experience or resulting in downtime.

The stateless operation of Wanguard Sensor and Wanguard Filter ensures detection and mitigation of volumetric attacks that may cripple even the most powerful stateful devices such as firewalls, Intrusion Detection Systems (IDS) or Intrusion Protection Systems (IPS). This is why, in most cases, the servers running Wanguard should be installed near the network's entry points, in front of other stateful devices. The single major disadvantage of the stateless operation is that Wanguard Sensor and Wanguard Filter are unable to detect and block low-volume application layer (OSI Layer 7) attacks, unlike traditional IPSes.

There are several Wanguard Filter "flavors", each having a different way of obtaining traffic information:

- **Packet Filter** analyzes packets passing through appliances (servers, firewalls, routers, bridges, IDSes, load-balancers) deployed in-line, connected to a mirrored port, or that make use of BGP traffic diversion. It needs to run on a powerful server to be able to do packet inspection on high-speed interfaces. Each configuration option is covered on page 60
- **Flow Filter** analyzes NetFlow®, sFlow® or IPFIX flow data. It works only in cooperation with Flow Sensor, therefore it is not able to generate filtering rules as fast as Packet Filter. Because flows provide a limited amount of traffic information, filtering rules generated from flows can contain only IP addresses, TCP ports, UDP ports and IP protocols. Each configuration option is covered on page 66
- **Filter Cluster** aggregates traffic data collected by multiple Packet Filter and Flow Filter instances. It can be used to create clusters of filtering servers. Each configuration option is covered on page 67

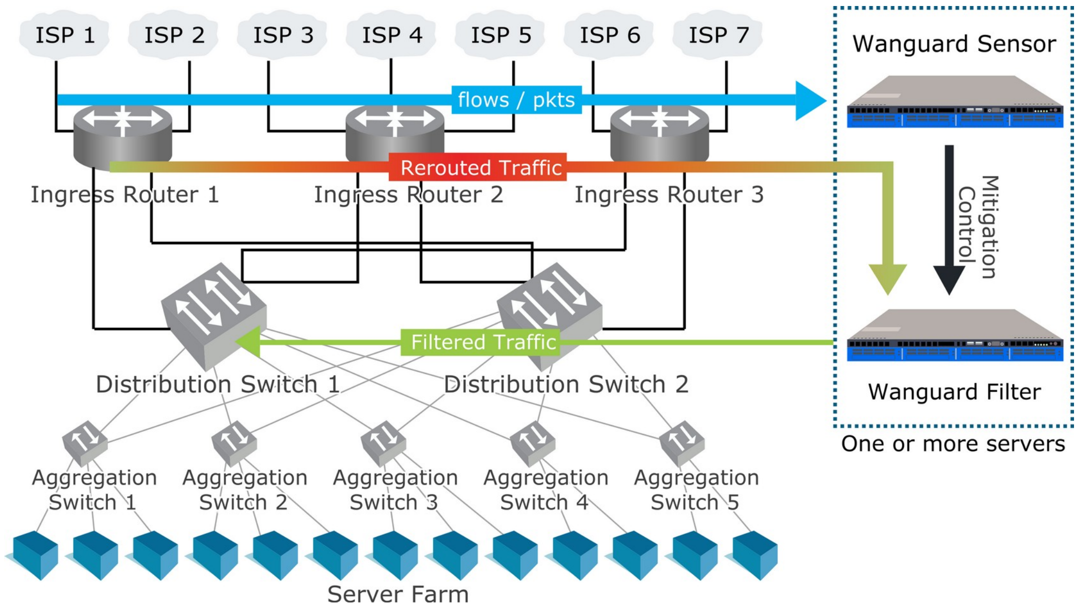
Technologies used by Wanguard Filter for DDoS mitigation		
PF_RING + Netfilter / Libpcap + Chelsio	**BGP FlowSpec**	**DPDK**
Throughput		
Relatively small throughput. The Linux kernel performs the routing, so there are scaling issues above 10 Gbps with small packets due to its use of interrupts. The filtering is done either by the kernel, or by the Chelsio chipset (these inexpensive 10/40/100 Gbps NICs are able to filter most attack patterns at wire speed). PF_RING is faster than Libpcap but it does not support Chelsio.	A single Flow Filter instance can mitigate >1 Tbps attacks without any problem. Works very well on modest hardware because it uses pre-aggregated flows instead of packets, and the router performs the filtering and the routing.	With DPDK, a single Intel Xeon 6212U CPU is able to switch and filter around 50 Mpps between two 100 Gbps interfaces, which make Packet Sensor and Packet Filter fast enough to use inline.
Delays		
Packet Sensor detects attacks within 5 seconds by default, but can be configured to detect attacks within 1 second. After detection, it starts Packet Filter which needs <1 second to divert traffic and <5 seconds to detect and apply filtering rules.	Depends on the router's flow aging configuration. Routers typically export flows after 30-120 seconds. Flow Sensor detects the attack within 20 seconds. Flow Filter generates filtering rules within 5-10 seconds. The BGP routing update takes around 1 second.	In DPDK mode, Packet Sensor can detect attacks in under 1 second. Packet Filter needs up to 5 seconds to detect attack patterns and apply filtering rules. With DPDK the packets are processed and forwarded in bulk (configurable, minimum 4), adding latency to low volume traffic.
Reliability		
Old and proven solution, very well tested.	Recent solution, well tested.	New solution, poorly tested; deemed as experimental. When used inline, it becomes a single point of failure.

Flexibility		
Extremely flexible and easy to troubleshoot. Netfilter is able to filter all attack patterns, including countries and packet payloads. It can do bridging, routing, use NICs offload functions, allows third-party tools to inspect packets.	Flow protocols are not collecting useful traffic information about TCP flags, IP fragments, packet sizes, TTL, etc, so a limited number of attack patterns can be detected and filtered.	Supports more filtering rules than Flowspec but fewer than Netfilter. In inline mode it can't do routing. The kernel and other programs are isolated from the NIC, which is used exclusively by a single process which incorporates Packet Sensor's and Packet Filter's logic.
Network Integration		
Very simple to configure at the host level. At the network level, a BGP expert might be needed because it requires BGP routers for traffic diversion.	Requires edge routers with support for BGP FlowSpec. (e.g. Juniper MX). Relatively simple to configure. A network expert is needed to configure exabgp and the router.	Much harder to configure and optimize. Once configured, it can be easily installed as an inline bridge, which makes it very easy to integrate into the network. In this case, no BGP is required. Can be configured for traffic diversion via BGP, but since it has no real TCP/IP stack the functionality is severity limited.
Attack Details		
Can capture and save malicious packets for proof and forensic investigation. Packet counters are available for the traffic filtered by Netfilter or by the Chelsio NIC.	Flow data is saved in a compressed format and can be inspected at any later date. Packet counters are not yet available for the filtered traffic.	Currently it is not possible to capture packets and save packet dumps in DPDK mode. Packet counters are available for the filtered traffic.
Hardware Considerations		
Works better with CPUs with fewer cores but very high frequency. PF_RING supports only few NIC chipsets. Libpcap supports all NICs.	No special hardware is necessary.	The architecture is optimized for many CPU cores, so CPUs with lots of cores are better than CPUs with fewer cores but higher frequency. Supports more NICs than PF_RING. Dual-socket systems are not recommended (inter-socket speed is too low).
Power Consumption		
Moderate power consumption. When not deployed inline, the CPUs are used only during attacks.	Very low power consumption.	High power consumption under the current "run-to-completion" model. Uses CPUs at 100% even on 0 traffic.
Licensing		
Packet Sensor needs a license for each sniffed interface when it uses Libpcap. With PF_RING it is possible to use a single Packet Sensor for multiple interfaces. Packet Filter needs a license for each interface that receives traffic that needs cleaning.	Flow Sensor needs a license for each flow exporter, irrespective of the number of interfaces of the flow exporter. Flow Filter needs a single license even if it is used by multiple Flow Sensors.	In DPDK mode, Packet Sensor can listen and perform packet switching between many interfaces, on the same server, with a single license. Packet Filter needs as many licenses as Packet Sensor.

Packet Filter Deployment Scenarios

Packet Filter can be deployed on servers configured for:

- **Side-filtering** – Packet Filter sends a BGP routing update to a border router (or route reflector) that sets its server's IP as next hop for the suspect traffic. The cleaned traffic is routed back into the network using static or dynamic routing. For more details see Appendix 4 on page 114



- **In-line routing** – Packet Filter runs on a server that resides in the main data path, configured as router
- **In-line network bridging** – Packet Filter runs on a server that resides in the main data path, configured as an OSI Layer 2 Linux network bridge
- **Out-of-line monitoring** – Packet Filter runs on a server connected outside the main data path and which receives a copy of packets from a TAP or mirroring port. The filtering rules improve the visibility of attacks and can be applied via helper scripts or BGP Flowspec on other in-line appliances, routers, switches or firewalls
- **Local protection** – Packet Filter runs as a service on each Linux server that provides critical services. The filtering rules are applied using the local firewall

System Requirements and Software Installation

Installing Wanguard will not generate any negative side effects on the network's performance. Full installation and configuration may take less than an hour; after that, the network will be monitored and protected immediately. No baseline data gathering is required.

Wanguard runs exclusively on Linux platforms. To install and configure the software you need basic Linux operation skills and at least medium computer networking skills. If you encounter software installation issues or if you have questions about the system requirements listed below, please contact support@andrisoft.com.

System Requirements

Wanguard 8.0 can be installed on the following 64-bit Linux distributions: CentOS 7 or 8 (free, Red Hat-based), Red Hat Enterprise Linux 7 or 8 (commercial), Debian Linux 7 to 10 (free, community-supported), Ubuntu Server 14 to 20 (free, Debian-based).

Wanguard was designed to be completely scalable, so it can be installed either on a single server with adequate hardware resources or on multiple servers distributed across the network. It is highly recommended to install the software on dedicated servers and not on Virtual Machines, mainly because:

- Having fast and uninterrupted access to the hard disk is a critical requirement of the Console
- The resources must be provisioned in a predictable and timely manner
- Some virtualized environments do not have a stable-enough clock source

Importance of HW resources	**CPU Speed (> GHz/core)**	**CPU Cores (> cores)**	**RAM Size (> GB)**	**HDD Size (> GB)**	**HDD/SSD Speed (> Mbytes/s)**	**Network Adapter (Vendor, Model)**
Console	*High*	*High*	*High*	*Very High*	*Very High*	*Very Low*
Packet Sensor	*Very High*	*High*	*Medium*	*Low*	*Low*	*Very High*
Flow Sensor	*Low*	*Low*	*High*	*Medium*	*High*	*Very Low*
SNMP Sensor	*Very Low*	*Low*	*Very Low*	*Very Low*	*Very Low*	*Very Low*
Sensor Cluster	*Medium*	*Medium*	*Medium*	*Very Low*	*Very Low*	*Very Low*
Packet Filter	*Very High*	*Very High*	*Medium*	*Very Low*	*Very Low*	*Very High*
Flow Filter	*Low*	*Low*	*High*	*Very Low*	*Very Low*	*Very Low*
Filter Cluster	*Medium*	*Medium*	*High*	*Very Low*	*Very Low*	*Very High*

Legend	*Very High Importance*	*High Importance*	*Medium Importance*	*Low Importance*	*Very Low Importance*

Minimum System Requirements for Console

Capacity	<10 components (Sensors, Filters, BGP Connectors)
Architecture	64-bit x86
CPU	1x 2.4 GHz quad-core Xeon
RAM	1 x 8 GB
NICs	1 x Fast Ethernet for management
HDDs	2 x 7200 RPM HDD (SSD highly recommended), RAID 1, 350 GB

The Console server stores the database and centralizes all operational logs, graphs and IP accounting data. Its performance is determined by its configuration, the performance of the I/O and the performance of the applications it relies on: MySQL/MariaDB, Apache HTTPD and PHP.

To access the web interface, use one of the following web browsers: Google Chrome 64+, Firefox 52+, Safari 10+, Microsoft Edge 12+, Opera 43+. JavaScript and cookies must be enabled. Java and Adobe Flash are not required. For the contextual help you may need to install Adobe PDF Reader.

For the best experience, we recommend using Google Chrome and a 1280x1024 or higher resolution display.

Firefox shows mismatched colors on some PCs. You can fix it by enabling color management:

1. Type in about:config on your Firefox address bar
2. Use the filter field to search for color_management
3. Set gfx.color_management.mode to 1
4. Set gfx.color_management.enablev4 to true
5. Restart Firefox

Minimum System Requirements for Packet Sensor

Capacity	10 Gbit/s, 14 Mpkts/s (wire rate)	40 Gbit/s, ±30 Mpkts/s
Architecture	Intel Xeon 64-bit, dedicated server	Intel Xeon 64-bit, dedicated server
CPU	1x 2.4 GHz Xeon E5-2640v4	1 x 2.4 GHz Xeon E5-2680v4
RAM	4 x 2 GB DDR4 (quad channel)	4 x 8 GB DDR4 (quad channel)
NICs	1 x 10 GbE adapter (Intel 82599+ or PF_RING/DPDK-supported chipset) 1 x Fast Ethernet for management	1 x 40 GbE adapter (Intel XL710+ or other DPDK-supported chipset) 1 x Fast Ethernet for management
HDDs	2 x 5400 HDD, RAID 1, 10 GB (including OS)	2 x 5400 HDD, RAID 1, 10 GB (including OS)

Packet Sensor can run load-balanced over multiple CPU cores with the following hardware / Capture Engines:

- Intel 82599 chipset network adapters, such as Intel X520, Intel X540, HP X560 or Silicom PE310G4DBi9-T
- PF_RING (with or without ZC) high-speed packet I/O framework

- Netmap high-speed packet I/O framework and its supported NICs
- Data Plane Development Kit (DPDK) and all its supported NICs

You can easily scale the Packet Sensor's capacity above 100 Gbit/s by enabling packet sampling on the switch or TAP, or by defining a Sensor Cluster that aggregates multiple Packet Sensor instances running on different servers equipped with 10, 40 or 100 Gbit/s network adapters.

Minimum System Requirements for Flow Sensor

Capacity	15000 flows/s
Architecture	64-bit x86
CPU	1 x 2.0 GHz dual-core Xeon
RAM	1 x 8 GB
NICs	1 x Fast Ethernet for management
HDDs	2 x 7200 RPM HDD, RAID 1, 60 GB

Flow Sensor can monitor an almost unlimited number of interfaces. On modern hardware, the processing of tens of thousands of flows/s is also not a problem. Each Flow Sensor can handle the flows of a single flow exporter. Any server with enough RAM can run tens of Flow Sensor instances. For this type of Sensor, the amount of RAM is much more important than the speed of the CPU.

Flow Sensor can store flow data on the local disk in a highly compressed binary format.

Minimum System Requirements for SNMP Sensor

Capacity	20+ devices
Architecture	64-bit x86
CPU	1 x 1.6 GHz dual-core Xeon
RAM	1 x 1 GB
NICs	1 x Fast Ethernet for management
HDDs	2 x 5200 RPM HDD, RAID 1, 20 GB

Each SNMP Sensor can monitor a single device with an unlimited number of interfaces. Any server can run an almost unlimited number of SNMP Sensor instances.

Minimum System Requirements for Sensor Cluster

The hardware requirements for Sensor Cluster are very low because the traffic information is pre-aggregated by the associated Flow Sensor, Packet Sensor or SNMP Sensor instances. It is best to run it on the Console server.

Minimum System Requirements for Packet Filter

Capacity	10 Gbit/s, 14 Mpkts/s	40 Gbit/s, >30 Mpkts/s
Architecture	Intel Xeon 64-bit, dedicated server	Intel Xeon 64-bit, dedicated server
CPU	1 x 2.4 GHz Intel Xeon E5-2640v4	1 x 2.4 GHz Intel Xeon E5-2690v4
RAM	4 x 2 GB DDR4 (quad channel)	4 x 8 GB DDR4 (quad channel)
NICs	2 x 10 GbE interfaces (Chelsio T5+, Intel X520+, or other DPDK-supported chipset) 1 x Fast Ethernet for management	2 x 40 GbE interfaces (Chelsio T5+, Intel XL710+, or other DPDK-supported chipset) 1 x Fast Ethernet for management
HDDs	2 x 5200 RPM HDD, RAID 1, 35 GB	2 x 5200 RPM HDD, RAID 1, 35 GB

The main task of Packet Filter is to inspect the traffic flooding the attacked IP destination(s) and to generate dynamic filtering rules that isolate the malicious packets. When it generates a filtering rule, it announces it to the Console and applies it on the local Netfilter firewall, embedded Dataplane firewall, in-NIC hardware filter, BGP Flowspec-capable router or third-party filtering appliance.

The firewall backends used by Packet Filter have no need for the connection tracking mechanism specific to stateful firewalls and IPSes. This ensures a much better filtering and routing performance during spoofed attacks and SYN floods. However, the filtering and packet-forwarding capacity may still not be line-rate, especially during powerful attacks with small packets. Packet Filter has line-rate packet filtering only on:

- Chelsio T5+ network adapters. On the Chelsio T5 or T6, Packet Filter is able to program 486 LE-TCAM filter rules to block traffic for source/destination IPv4/IPv6 addresses, source/destination TCP/UDP ports and IP protocols
- Intel 82599 chipset network adapters, such as Intel X520, Intel X540, HP X560. Packet Filter is able to program 4096 filter rules to block IPv4 addresses, but either sources or destinations, not both
- Servers meeting the minimum system requirements configured to use the DPDK Capture Engine and the embedded Dataplane Firewall
- Some adapters supporting the DPDK Flow API

To scale the packet filtering capacity above 100 Gbits/s, either use BGP Flowspec or split the traffic with a hardware load balancer or by using equal-cost multi-path routing. You can then configure a Filter Cluster to aggregate multiple Packet Filter instances running on different servers equipped with 10/40/100 Gbit/s network adapters.

Minimum System Requirements for Flow Filter

The hardware requirements for Flow Filter are very low because it analyzes traffic information pre-aggregated by Flow Sensor. If Flow Filter is used only for reporting and not for packet filtering, it is best to run it on the same server with the Console.

Flow Filter can apply filtering rules just the same as Packet Filter. The requirements for software-based and/or hardware-based traffic filtering are listed in the previous section.

Minimum System Requirements for Filter Cluster

Filter Cluster groups, aggregates and controls multiple Packet Filter and/or Flow Filter instances.

The hardware requirements for Filter Cluster are very low because the traffic information is pre-aggregated by the associated Filter instances. If Filter Cluster is used only for reporting and not for packet filtering, it is best to run it on the same server with the Console.

Filter Cluster can apply filtering rules just the same as Packet Filter and Flow Filter. The requirements for software-based and/or hardware-based traffic filtering are listed in the Packet Filter Hardware Requirements section.

Software Installation

The download link is listed in the email with the trial license key. The latest software installation instructions are listed on www.andrisoft.com.

Each trial license key activates all features for 30 days. You can install the trial license key on any number of servers. To switch to a full, registered version, apply a license key purchased from the online store.

Opening the Console

Wanguard Console provides a web interface and centralized system through which you can control and monitor all the other components. If you have correctly followed the installation instructions, from now on you will only need to log in to Console to manage and monitor servers and software components. SSH access will be needed for updating the software.

Open the Console at http://<console_hostname>/wanguard. If the page cannot be displayed, make sure that the Apache web server is running and the firewall does not block incoming traffic on port 80 or 443. You can also access it securely via HTTPS if the Apache web server was configured to serve pages over SSL/TLS.

If you have not licensed Wanguard, you will be asked to do so. Upload the *trial.key* file emailed to you by clicking the key icon. The license key contains encrypted information about the licensed capabilities of the software. You can replace the license key in Configuration » General Settings » License Manager.

Log in to the Console using the default username/password combination: **admin**/**changeme**.

If the Console is installed on a public server, you should immediately change the default password of the “admin” account. To do so, click the **Admin** menu at the top-right corner of the browser window and select [**Change Password**]. From the same menu you can change the Console layout and theme.

To understand how to navigate within the Console, read the dedicated chapter on page 20.

Licensing Procedure

When the trial period is over you will have to purchase as many Sensor and Filter licenses, in form of annual subscriptions, as the number of Sensors and Filters configured and enabled in Configuration » Components.

- ➢ You will have to purchase as many Sensor licenses as the number of flow exporters (usually border or edge routers) monitored by Flow Sensors. There is no limit on the number of interfaces a Flow Sensor can monitor.
- ➢ You will have to purchase as many Sensor licenses as the number of interfaces (ports) listened by Packet Sensors. Multiple Packet Sensors listening to the same interface (e.g. when using a multi-queue NIC) use a single Sensor license. Packet Sensor can monitor an unlimited number of IPs/domains
- ➢ You can mix Wanguard Sensor licenses together with Wansight Sensor licenses
- ➢ You will need as many Wanguard Filter licenses as the number of Filters enabled in Configuration » Components. A single Packet Filter can clean the traffic received from multiple parts of the network, but it can listen to a single interface (port). Multiple Flow Sensors can use a single Flow Filter. Wanguard Filter works only in conjunction with Wanguard Sensor
- ➢ Sensor Cluster and Filter Cluster do not require licensing
- ➢ Console does not require licensing

You can distribute the licensed Sensors and Filters on any number of servers without additional licensing costs. The license key must contain the hardware keys listed under Configuration » General Settings » License Manager » Requirements. The minimum licensing period is 12 months and the maximum licensing period is 48 months.

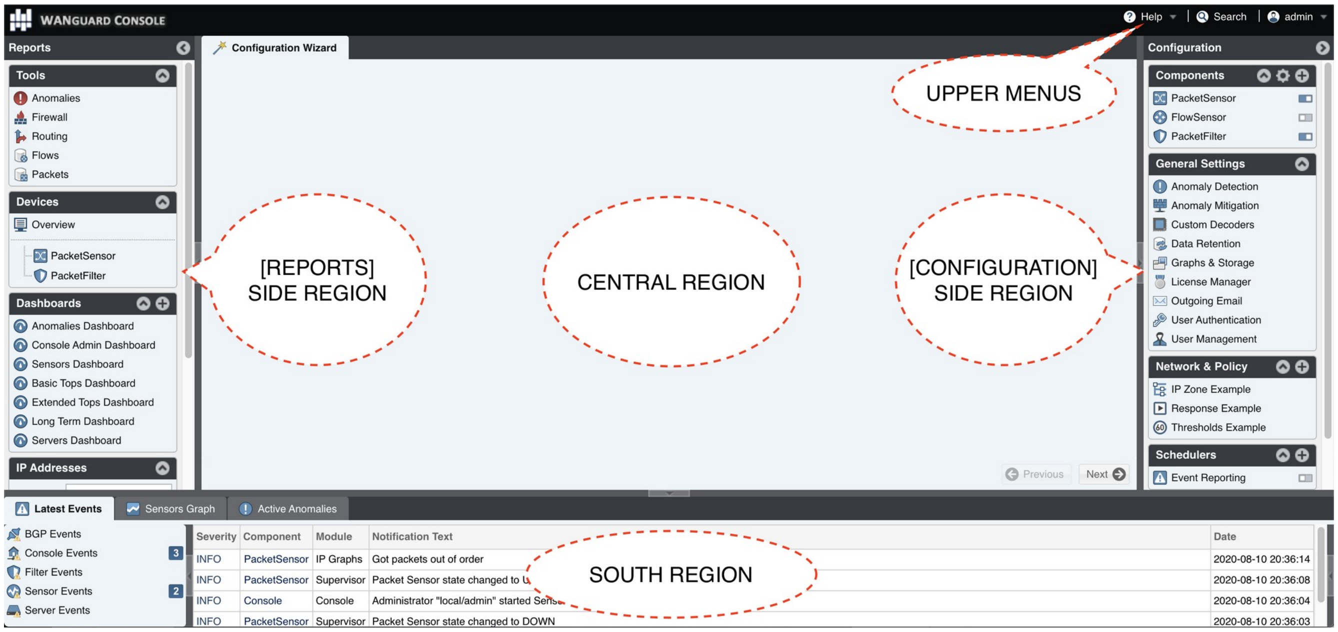
Quick Configuration Steps

- ➔ Estimate storage requirements, review decoders and IP graph settings – page 22
- ➔ Setup anomaly detection parameters and decoders – page 28
- ➔ Configure the reaction to traffic anomalies – page 32
- ➔ Add your IP address ranges and important hosts to an IP Zone – page 35
- ➔ Configure anomaly detection for prefixes, create threshold templates – page 36
- ➔ Configure a Packet Sensor – page 41, Flow Sensor – page 45, or SNMP Sensor – page 50
- ➔ Configure BGP Connectors for black hole routing, traffic diversion or Flowspec – page 55
- ➔ For DDoS mitigation configure a Packet Filter – page 60, or a Flow Filter – page 66
- ➔ Generate reports and send them periodically by email – page 68
- ➔ Watch the event log. Receive error notifications by email – page 69
- ➔ Create personalized Console accounts for your staff or customers – page 71
- ➔ Create dashboards and add widgets containing useful information – page 99

Basic Concepts of Wanguard Console

Please read this chapter in order to understand the basic premises required to properly operate the software. The next few chapters cover the software's configuration, while the last chapters cover the reporting features.

To understand how to operate the Console web interface you should be aware of its structure:



Severity	Component	Module	Notification Text	Date
INFO	PacketSensor	IP Graphs	Got packets out of order	2020-08-10 20:36:14
INFO	PacketSensor	Supervisor	Packet Sensor state changed to U	2020-08-10 20:36:08
INFO	Console	Console	Administrator "local/admin" started Sens	2020-08-10 20:36:04
INFO	PacketSensor	Supervisor	Packet Sensor state changed to DOWN	2020-08-10 20:36:03

Side Region

Is located at the east and/or west edge of the browser's window, according to the user's preference. If it is not visible, it has been either collapsed or hidden by an administrator. Clicking the edge of regions expands or collapses them.

Side Region contains 2 sections – Reports and Configuration – that can be collapsed or expanded by clicking the title bars or by pressing Ctrl+R. Both sections contain multiple panels that can also collapse or expand, with such state being maintained between sessions. These panels are constantly updated.

Central Region

Each report, dashboard or tool you select in the Side Region opens a tab (page) in the Central Region. You can switch between (sub-) tabs with a mouse or with the keyboard shortcut (Alt+) Ctrl+→ and (Alt+)Ctrl+←. You can close all tabs except for the Landing Tab (initially set as the Configuration Wizard). To change the Landing Tab, edit your user profile in Configuration » General Settings » User Management. Tabs can be rearranged with drag-and-drop.

South Region

South Region provides a quick way to view live data such as events (system logs) or animated traffic graphs. It is located at the bottom of the browser's window. By default, it is collapsed; to expand it, click the thin line near the lower edge or press Ctrl+E.

Upper Menus

The Help menu contains links to the User Guide, to various helper tools and to Software Updates. Depending on context, the User Guide opens the chapter describing the last-opened window or tab.

The “Quick Search” button allows you to open tabs with the keyboard. Keyboard shortcut: Ctrl+S.

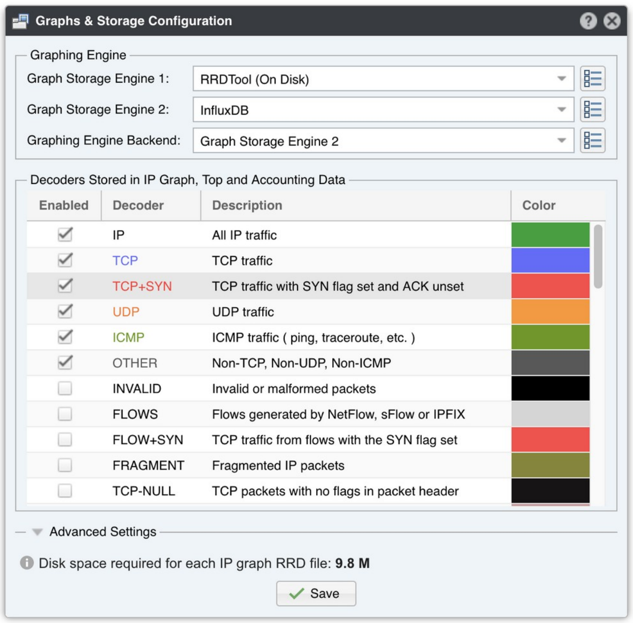
The User menu provides a Log Out option, lets you quickly change the password, the UI layout and the theme.

Configuration » General Settings » Graphs & Storage

An important initial step in configuring Wanguard is to make sure that the servers the software runs on have enough resources to collect IP graphs, flows and packet dumps.

In a later chapter, you will be able to configure Sensors to generate traffic graphs, tops and accounting data for every IP that belongs to the monitored network. If you intend to use this feature, you may want to change the IP storage settings, as changing these later might require a reset of all existing IP graph, top and accounting data.

All storage-related settings are located in Configuration » General Settings » Graphs & Storage.


Graphs & Storage Configuration

Graphing Engine

Graph Storage Engine 1: RRDTool (On Disk)
Graph Storage Engine 2: InfluxDB
Graphing Engine Backend: Graph Storage Engine 2

Decoders Stored in IP Graph, Top and Accounting Data

Enabled	Decoder	Description	Color
✓	IP	All IP traffic	🟩
✓	TCP	TCP traffic	🟦
✓	TCP+SYN	TCP traffic with SYN flag set and ACK unset	🟥
✓	UDP	UDP traffic	🟧
✓	ICMP	ICMP traffic (ping, traceroute, etc.)	🟩
✓	OTHER	Non-TCP, Non-UDP, Non-ICMP	⬛
☐	INVALID	Invalid or malformed packets	⬛
☐	FLOWS	Flows generated by NetFlow, sFlow or IPFIX	⬜
☐	FLOW+SYN	TCP traffic from flows with the SYN flag set	🟥
☐	FRAGMENT	Fragmented IP packets	🟫
☐	TCP-NULL	TCP packets with no flags in packet header	⬛

Advanced Settings

Disk space required for each IP graph RRD file: **9.8 M**

The **Graph Storage Engine** parameter lets you choose which third-party software will store the graph data:

- **RRDTool** is installed and enabled by default. It is very stable but in some cases it can be slow (due to the disk seek time), it uses a lot of storage space (due to its preallocation of data), and some configuration changes (e.g. adding a decoder) resets the existing graph data
- **InfluxDB** is a database created specifically to store time series data. It uses more RAM than RRDTool but it needs less storage space, it is faster in many cases, it can be configured for High Availability, and existing data is not deleted by configuration changes

Wanguard can use **Graph Storage Engine 1** as the only backend, or it can use two backends at the same time in the following combinations: RRDTool + InfluxDB, or InfluxDB (primary) + InfluxDB (secondary). Click on the options button from the right to configure the selected engine.

- **RRDTool (On Disk)** – This method optimizes the long-term storage of IP graph data by allowing up to three **Round Robin Archives**. The values within the Round Robin Archives determine the granularity of the graphs and the interval of time they are saved. These entries specify for how long, and how accurately the data should be stored. A smaller data average (5 seconds minimum) generates a very accurate graph, but requires more disk space, while a bigger data average (5 minutes maximum) is less accurate but uses less disk space.

RRDTool stores each graph in a separate file, therefore on non-SSD drives the disk seek time may be too high to update thousands of IP graph files every few minutes. If this is the case, configure the **RRDCached Socket** to increase the I/O performance of the Console server (KB article link). If the speed of updating IP graph files is still not fast enough, consider the other options listed below. **Graph Data Units** lets you choose the data units stored inside IP graph files. **Graph Consolidation** lets you choose how to build consolidated values for Round Robin Archives. If you are interested in traffic spikes, check MAXIMUM. If you are interested in average values, check AVERAGE. For low traffic values, check MINIMUM

- **RRDTool (In RAM)** – This method is not optimal for long-term storage because it allows a single Round Robin Archive per IP graph file. The files are created and updated in the **Graphs RAM Path**, and moved periodically onto a larger, albeit slower disk. Select this method when you can't use InfluxDB and when the previous method (configured with RRDCached) is not fast enough to sustain updating thousands of very high-granularity IP graphs. The other parameters are explained by the previous paragraph
- **InfluxDB** – This is the recommended graph storage engine. The configuration steps are mandatory:
  - In the **InfluxDB URL** field enter the full URL of the InfluxDB http(s) server (e.g. http://127.0.0.1:8086)
  - **InfluxDB Username** and **InfluxDB Password** are optional and should be set if *auth-enabled=true* in influxdb.conf
  - **InfluxDB Database** is optional. By default, the name of the InfluxDB database is "andrisoft". The field should be set only when using a single InfluxDB for multiple Consoles.
  - Click on the **<Initialize InfluxDB>** button to create a new InfluxDB database called "andrisoft"

The **Graphing Engine Backend** parameter lets you choose from which Graph Storage Engine to pull the data when rendering graphs.

Decoders represent internal functions that differentiate and classify the underlying protocols of each packet or flow. Each enabled decoder increases the size of IP graph, top and accounting data, and causes a small performance penalty. It is recommended to enable only the decoders you are interested in. You can define your own decoders in Configuration » General Settings » Custom Decoders. Built-in decoders:

DECODER	DESCRIPTION
IP	Matches all IP packets, irrespective of higher protocols. Always enabled
TCP	Matches TCP traffic
TCP+SYN	Matches TCP traffic with SYN flag set and ACK unset. Flow Sensor counts one packet per flow
UDP	Matches UDP traffic
ICMP	Matches ICMP traffic
OTHER	Matches IP protocols that differ from TCP, UDP and ICMP
INVALID	Matches TCP or UDP port set to 0, or IP protocol set to 0
FLOWS	Matches flow records and replaces packets/s with flows/s. Works only with Flow Sensor
FLOW+SYN	Matches flow records with SYN flag set. Flow Sensor counts all packets per flow
FRAGMENT	Matches fragmented IP packets. Works only with Packet Sensor

TCP-NULL	Matches TCP traffic without TCP flags, indicative of reconnaissance sweeps
TCP+RST	Matches TCP traffic with RST flag set
TCP+ACK	Matches TCP traffic with SYN flag unset and ACK set
TCP+SYNACK	Matches TCP traffic with SYN flag set and ACK flag set
NETBIOS	Matches TCP traffic on source or destination port 139
QUIC	Matches Google’s QUIC protocol on UDP port 80 and 443
UDP-QUIC	Matches UDP traffic not part of the QUIC protocol
MEMCACHED	Matches UDP traffic on port 11211
HTTP	Matches TCP traffic on source or destination port 80
HTTPS	Matches TCP traffic on source or destination port 443
MAIL	Matches TCP traffic on source or destination ports 25, 110, 143, 465, 585, 587, 993, 995
DNS	Matches UDP traffic on source or destination port 53
SIP	Matches TCP or UDP traffic on source or destination port 5060
IPSEC	Matches IP traffic on IP protocol 50 or 51
WWW	Matches TCP traffic on source or destination ports 80, 443
SSH	Matches TCP traffic on source or destination port 22
NTP	Matches UDP traffic on source or destination port 123
SNMP	Matches UDP traffic on source or destination ports 161, 163
RDP	Matches TCP or UDP traffic on source or destination port 3389
YOUTUBE	Matches IP traffic going or coming from Youtube AS 43515, 36561, or from Youtube subnets
NETFLIX	Matches IP traffic going or coming from Netflix AS 55095, 40027, 2906, or from Netflix subnets
HULU	Matches IP traffic going or coming from Hulu AS 23286, or from Hulu subnets
FACEBOOK	Matches IP traffic going or coming from Facebook AS 54115, 32934, or from Facebook subnets

In most cases it is safe to ignore the parameters under the **Advanced Settings** section.

Graph IP Sweeps option allows storing IP graph data for IPv4 and/or IPv6 addresses that receive traffic without sending any traffic back. Do not set it to “Off” when monitoring unidirectional links or asymmetric traffic.

Sensor Top N (default: 20) specifies the maximum number of items stored for ordered sets of data, such as top Talkers, External IPs, ASNs, Countries, TCP/UDP ports, IP protocols, and so on.

Packet Sensor saves packet dumps on the local disk in the path defined in the **Packet Dump Path** field. Flow Sensor saves flow data on the local disk in the path defined in the **Flow Collector Path** field. When the Console is not installed on the same server that runs the Sensor, export these paths towards the Console's file system using an NFS share (KB article link). If you do not, the Console is not able to display data saved on remote servers.

RRDTool stores all graph files on the Console server, in the **Graphs Disk Path**. Graph files are optimized for storing time series data and do not grow over time. All IP graph options have a direct impact on the storage space required on the Console server. The size of each IP graph file is listed on the bottom of the window in the ***Disk space required for each IP graph file*** field. When Sensor Clusters are not used, the maximum number of IP graph files that could be generated can be calculated with the formula: ((number of Packet Sensors) + (number of Flow Sensor interfaces)) x (number of IPs contained in subnets with IP Graphing set to “Yes” in the IP Zone).

It is highly recommended to automate the deletion of old data and to monitor the disk usage of IP graphs in Configuration » General Settings » Data Retention.

Sensor and Applications Graph Troubleshooting

- ✔ Ensure that all Sensors run correctly by verifying the event log and by viewing live statistics from Reports » Devices » Overview. The troubleshooting guide for Packet Sensor is located on page 43, for Flow Sensor on page 48 and SNMP Sensor on page 52
- ✔ Discontinuous Sensor graphs can be caused by enabling IP Accounting for too many/large subnets when there is a slow connection between the Sensor and the MySQL/MariaDB running on the Console server

IP/Subnet and Profiling Graph Troubleshooting

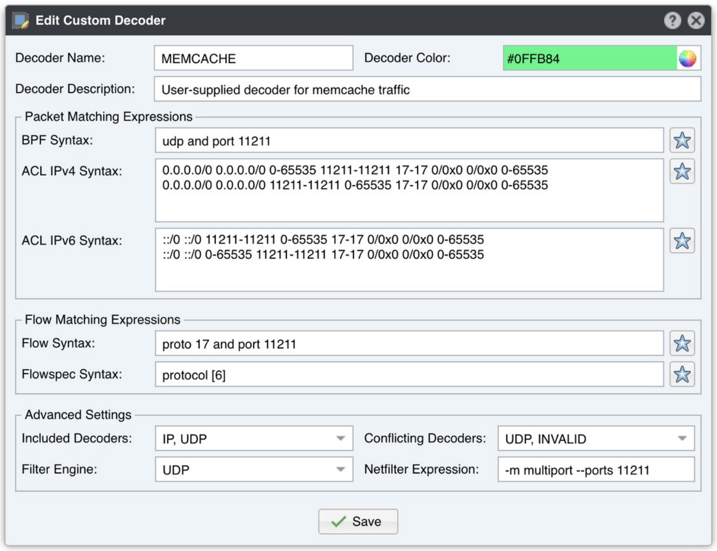
- ✔ Ensure that all Sensors run correctly by verifying the event log and by viewing live statistics displayed in Reports » Devices » Overview. The troubleshooting guide for Packet Sensor is located on page 43, for Flow Sensor on page 48 and SNMP Sensor on page 52
- ✔ Generating IP and profiling graph data causes the biggest impact on the load of the Console server. Enable each feature (IP graphing, IP accounting, IP profiling) sequentially for each subnet, after making sure that the Console server can handle it. The storage requirements for each subnet are listed in the IP Zone, and the current disk usage in Configuration » General Settings » Data Retention
- ✔ The internal process used for saving IP graph data is */opt/andrisoft/bin/genrrds_ip*. If it is overloading the Console server or the event log contains warnings such as “Updating IP graph data takes longer than 5 minutes”, use InfluxDB or RRDCacheD, RAM/SSD updating method, faster disk drivers, enable IP graphing for fewer subnets, or deploy a Sensor Cluster configured to aggregate IP graph data
- ✔ The internal process used for generating IP or subnet graphs is */opt/andrisoft/bin/gengraph_ip*. Console users launch the process for each requested IP or subnet graph. If the Console server gets too loaded by gengraph_ip, execute “killall gengraph_ip” and configure InfluxDB or RRDCacheD. When launched, the process stops only when the graph is generated. This process can be slow when users request subnet graphs for subnets not specifically defined in the IP Zone. It is not possible to throttle the number of graphs requested by users

AS and Country Graph Troubleshooting

- ✔ Ensure that all Sensors run correctly by verifying the event log and by viewing live statistics from Reports » Devices » Overview. The troubleshooting guide for Packet Sensor is located on page 43, for Flow Sensor on page 48 and SNMP Sensor on page 52
- ✔ To enable AS and Country graphs, set the Stats Engine parameter to either “Extended” for Flow Sensor, or “Full” for Packet Sensor
- ✔ SNMP Sensor is not able to generate AS graphs or Country graphs

Configuration » General Settings » Custom Decoders

Decoders represent internal functions that differentiate and classify the underlying protocols of each packet and flow. The predefined decoders are listed in the “Graphs & Storage” chapter on page 22. If you do not need to define custom decoders, you can safely skip this section.



Decoder Name: MEMCACHE
Decoder Color: #0FFB84
Decoder Description: User-supplied decoder for memcache traffic

Packet Matching Expressions

BPF Syntax: udp and port 11211

ACL IPv4 Syntax:
```
0.0.0.0/0 0.0.0.0/0 0-65535 11211-11211 17-17 0/0x0 0/0x0 0-65535
0.0.0.0/0 0.0.0.0/0 11211-11211 0-65535 17-17 0/0x0 0/0x0 0-65535
```

ACL IPv6 Syntax:
```
::/0 ::/0 11211-11211 0-65535 17-17 0/0x0 0/0x0 0-65535
::/0 ::/0 0-65535 11211-11211 17-17 0/0x0 0/0x0 0-65535
```

Flow Matching Expressions

Flow Syntax: proto 17 and port 11211
Flowspec Syntax: protocol [6]

Advanced Settings

Included Decoders: IP, UDP
Conflicting Decoders: UDP, INVALID
Filter Engine: UDP
Netfilter Expression: -m multiport --ports 11211

To manage user-defined decoders go to Configuration » General Settings » Custom Decoders.

Each custom decoder is defined by:

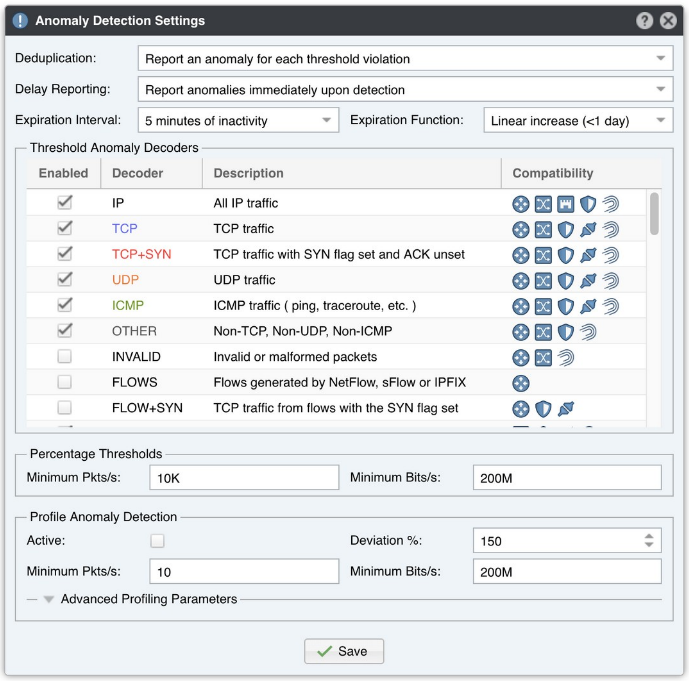
- **Decoder Name** – A short name to help you identify the decoder. This field is mandatory
- **Decoder Color** – The color used in graphs for the decoder. The default color is a random one, which can be changed by entering a different HTML color code or by clicking the drop-down menu
- **Decoder Description** – An optional short description of the decoder
- **BFP Syntax** – This syntax is used by Packet Sensor and Packet Filter when the Capture Engine option is not set to DPDK. Click the star icon on the right to see details about the correct syntax. Examples:
  - To match TCP packets with the SYN flag set, enter *tcp[tcpflags] & tcp-syn!=0*
  - To match UDP packets with the destination port under 1024, enter *proto 17 and dst portrange 1-1023*
  - To match memcached packets, enter *proto 17 and port 11211*
- **ACL IPv4/IPv6 Syntax** – This syntax is used by Packet Sensor and Packet Filter when the Capture Engine option is set to DPDK. Click the star icon on the right to see a few examples and get all the details about the correct syntax
- **Flow Syntax** – This syntax is used by Flow Sensor and Flow Filter. Click the star icon on the right to see the correct syntax. Examples:
  - To match TCP flows having only the SYN flag set, enter *flags S and not flags AFRPU*
  - To match flows with the MPLS label0 set to 2, enter *mpls label0=2*

- To match memcached packets, enter *proto 17 and port 11211*

- **Flowspec Syntax** – Enter a Flowspec expression if you intend to use BGP Flowspec for traffic redirection or DDoS mitigation. Click the star icon on the right to open a window that shows you the correct syntax. Example:
  - To match memcached packets, enter *port 11211; protocol 17;*
- **Included Decoders** – Required if you plan to use the decoder for IP graphing. Select the decoders that include the matched traffic, or choose IP if not sure
- **Conflicting Decoders** – Required if you plan to use the decoder for IP graphing. Select the decoders that might match same traffic, but not always. The option is used only for displaying stacked decoders inside IP graphs
- **Filter Engine** – If you intend to use Wanguard Filter for anomalies detected using the decoder, select the most specific Filter engine that could analyze the traffic. Otherwise, select *disabled*
- **Netfilter Expression** – Enter Netfilter/iptables argument(s) that match the same traffic also matched by the decoder to prevent irrelevant packets from passing the Netfilter firewall

Configuration » General Settings » Anomaly Detection

The anomaly detection engine can be configured in Configuration » General Settings » Anomaly Detection. The detection of anomalies also needs to be enabled individually for each subnet defined in the IP Zone (details on page 35).



Anomaly Detection Settings

Deduplication:	Report an anomaly for each threshold violation
Delay Reporting:	Report anomalies immediately upon detection
Expiration Interval:	5 minutes of inactivity
Expiration Function:	Linear increase (<1 day)

Threshold Anomaly Decoders

Enabled	Decoder	Description	Compatibility
✓	IP	All IP traffic	
✓	TCP	TCP traffic	
✓	TCP+SYN	TCP traffic with SYN flag set and ACK unset	
✓	UDP	UDP traffic	
✓	ICMP	ICMP traffic (ping, traceroute, etc.)	
✓	OTHER	Non-TCP, Non-UDP, Non-ICMP	
☐	INVALID	Invalid or malformed packets	
☐	FLOWS	Flows generated by NetFlow, sFlow or IPFIX	
☐	FLOW+SYN	TCP traffic from flows with the SYN flag set	

Percentage Thresholds

Minimum Pkts/s:	10K
Minimum Bits/s:	200M

Profile Anomaly Detection

Active:	☐
Deviation %:	150
Minimum Pkts/s:	10
Minimum Bits/s:	200M

Deduplication prevents the reporting of multiple anomalies for the same attack when the attack is matched by multiple decoders which are included within each other. Without this feature, if you define a 500k pps threshold for the IP decoder, a 400k pps threshold for the TCP decoder and a 30k pps threshold for the TCP+SYN decoder, and a 600k pps TCP+SYN attack is being received, the Sensor will detect three anomalies, one for each decoder. With this feature on, the Sensor will report a single anomaly for the most specific decoder which in this case is TCP+SYN. Select the first option to disable this feature. Select the second option to enable it. Select the third option also to ignore anomalies for bits/s thresholds when similar anomalies exist for packets/s thresholds.

Delay Reporting can be used to avoid reporting of anomalies shorter than a predefined number of seconds.

Expiration Interval lets you select the number of minutes of inactivity before anomalies expire. The default value is 5 minutes.

Expiration Function can be used to increase (linearly or exponentially) the number of minutes of inactivity before recurring anomalies expire. The system takes into account similar anomalies received in the previous 7 days.

Wanguard Sensor detects traffic anomalies using two different methods:

- **Threshold Anomalies** are detected for user-defined threshold values. Thresholds can be defined inside IP Zones for the decoders enabled in the **Threshold Anomaly Decoders** list. Decoders are explained in the previous chapter. Enable only the decoders for which you will define thresholds.

Thresholds can include either absolute values (e.g. IP receives 100k UDP packets/s) or percentage values (e.g. IP receives 30% UDP packets/s). To prevent **Percentage Thresholds** from being triggered for small amounts of traffic, configure minimum packets/s and bits/s values. Percentage values are calculated based on the rates of the monitored interface, for the same decoder. E.g. for an interface that receives 100k UDP packets/s, a 30% UDP packets/s threshold defined for a single IP triggers an anomaly when the IP receives over 30k UDP packets/s

- **Profile Anomalies** are detected through a behavioral recognition approach. After enabling in IP Zone the profile anomaly detection for a subnet/host, the Console builds a behavioral traffic graph for a 24 hour period. You can see the graph in Reports » IP Addresses » [Subnet] » Profile Graphs. Wanguard Sensor detects any activity that deviates from the expected traffic levels of the protected subnets.

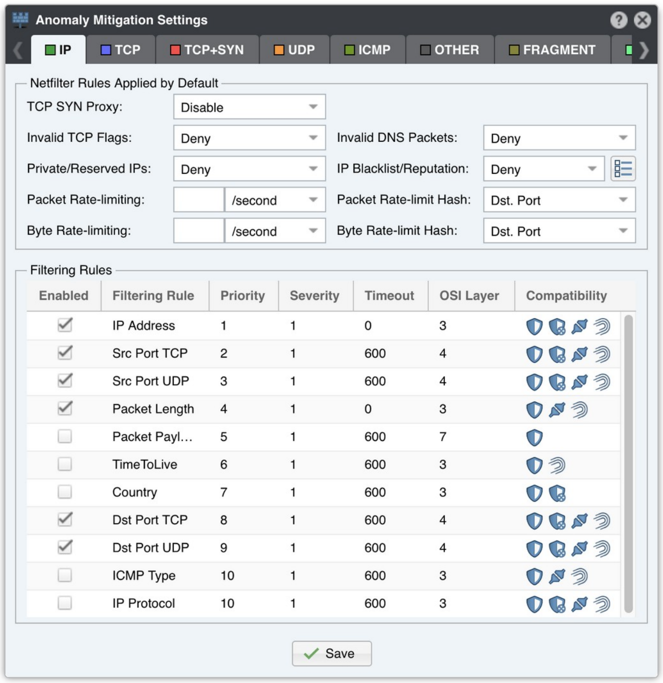
  Profile anomaly detection is recommended only for hosts and subnets that have a predictable traffic pattern. Larger subnets are usually more predictable. To prevent false positives, adjust the deviation percent and minimum packet and bit rates.

  Deviation % represents the maximum allowed deviation from the expected traffic before triggering a profile anomaly. A value of 100 allows traffic up to twice (100% expected + 100% deviation) the expected value

Users should not modify the values from the **Advanced Profiling Parameters** panel.

Configuration » General Settings » Anomaly Mitigation

In Configuration » General Settings » Anomaly Mitigation you can configure and fine-tune some advanced features of Wanguard Filter.



Netfilter Rules Applied by Default

TCP SYN Proxy:	Disable		
Invalid TCP Flags:	Deny	Invalid DNS Packets:	Deny
Private/Reserved IPs:	Deny	IP Blacklist/Reputation:	Deny
Packet Rate-limiting:	/second	Packet Rate-limit Hash:	Dst. Port
Byte Rate-limiting:	/second	Byte Rate-limit Hash:	Dst. Port

Filtering Rules

Enabled	Filtering Rule	Priority	Severity	Timeout	OSI Layer	Compatibility
✓	IP Address	1	1	0	3	🛡 ⛨ 🚀 📶
✓	Src Port TCP	2	1	600	4	🛡 ⛨ 🚀 📶
✓	Src Port UDP	3	1	600	4	🛡 ⛨ 🚀 📶
✓	Packet Length	4	1	0	3	🛡 🚀 📶
☐	Packet Payl…	5	1	600	7	🛡
☐	TimeToLive	6	1	600	3	🛡 📶
☐	Country	7	1	600	3	🛡 ⛨
✓	Dst Port TCP	8	1	600	4	🛡 ⛨ 🚀 📶
✓	Dst Port UDP	9	1	600	4	🛡 ⛨ 🚀 📶
☐	ICMP Type	10	1	600	3	🛡 🚀 📶
☐	IP Protocol	10	1	600	3	🛡 ⛨ 🚀 📶

All configuration options listed below are relevant only for the selected decoder.

- **TCP SYN Proxy** – When enabled, Wanguard Filter activates a SYN proxy mechanism included in recent Linux kernels immediately after its initialization. This mechanism shields servers from SYN flood attacks using a SYN proxy implementation to verify the WAN clients before forwarding their connection requests to the protected server. For this option to work, Wanguard Filter must be deployed inline and must receive both incoming and outgoing traffic.

  When the filtering server applies a SYN proxy to a TCP connection, it responds to the initial SYN packet with a manufactured SYN/ACK reply waiting for the ACK in response before forwarding the connection request to the server. Devices attacking with SYN flood packets do not respond to the SYN/ACK reply. The firewall identifies them by their lack of this type of response and blocks their spoofed connection attempts. SYN proxy forces the firewall to manufacture a SYN/ACK response without knowing how the server will respond to the TCP options normally provided on SYN/ACK packets.

  Some of the commands necessary to enable the SYN Proxy feature:

  ```
  echo 1000000 > /sys/module/nf_conntrack/parameters/hashsize
  /sbin/sysctl -w net/netfilter/nf_conntrack_max=2000000
  /sbin/sysctl -w net/netfilter/nf_conntrack_tcp_loose=0
  /sbin/sysctl -w net/ipv4/tcp_timestamps=1
  ```

- **Invalid TCP Flags** – When enabled, Wanguard Filter blocks all invalid TCP flags immediately after its activation. The necessary filtering rules for this option are applied by the Netfilter firewall for traffic forwarded to/from the attacked destination

- **Invalid DNS Packets** – When enabled, Wanguard Filter blocks all invalid DNS traffic (illegal combination of source port and destination port) immediately after its activation. The necessary filtering rules for this option are applied by the Netfilter firewall for traffic forwarded to/from the attacked destination
- **Private/Reserved IPs** – When enabled, Wanguard Filter blocks immediately after its activation all private or reserved IPv4 or IPv6 subnets. The necessary filtering rules for this option are applied by the Netfilter firewall for traffic forwarded to/from the attacked destination
- **IP Blacklist/Reputation** – When enabled, Wanguard Filter blocks all blacklisted IPs immediately after its activation. The necessary filtering rules for this option are applied by the Netfilter firewall for traffic forwarded to/from the attacked destination.

  The [**IP Blacklist Options**] button allows you to use predefined or to define your own sources that list IPs with a bad reputation. This option should be utilized only for a relatively small number of blacklisted IPs, as it may affect the firewall performance and the routing/forwarding process. The maximum number of blacklisted IPs is 65535
- **Packet Rate-limiting** – You can use this parameter to limit the rate of packets/time unit to a predefined value, or to a percentage of the anomaly threshold when the value entered ends with the character "%"
- **Packet Rate-limit Hash** – You can apply the packet rate-limiting globally, to a single object (*Src. IP*, *Src. Port*, *Dst. IP* or *Dst. Port*) or any combination of objects. If the rate-limiting should be connection-oriented, select all objects. To rate-limit the packet rate of each source IP, select the *Src. IP* object
- **Byte Rate-limiting** – You can use this parameter to limit the rate of bytes/time unit to a predefined value, or to a percentage of the anomaly threshold when the value ends with the character "%"
- **Byte Rate-limit Hash** – You can apply the byte rate-limiting globally, to a single object (*Src. IP*, *Src. Port*, *Dst. IP* or *Dst. Port*) or any combination of objects. If the rate-limiting should be connection-oriented, select all objects. To rate-limit the byte rate of each source IP, select the *Src. IP* object

The grid **Filtering Rules Settings** lets you view and edit the policy for each filtering rule type:

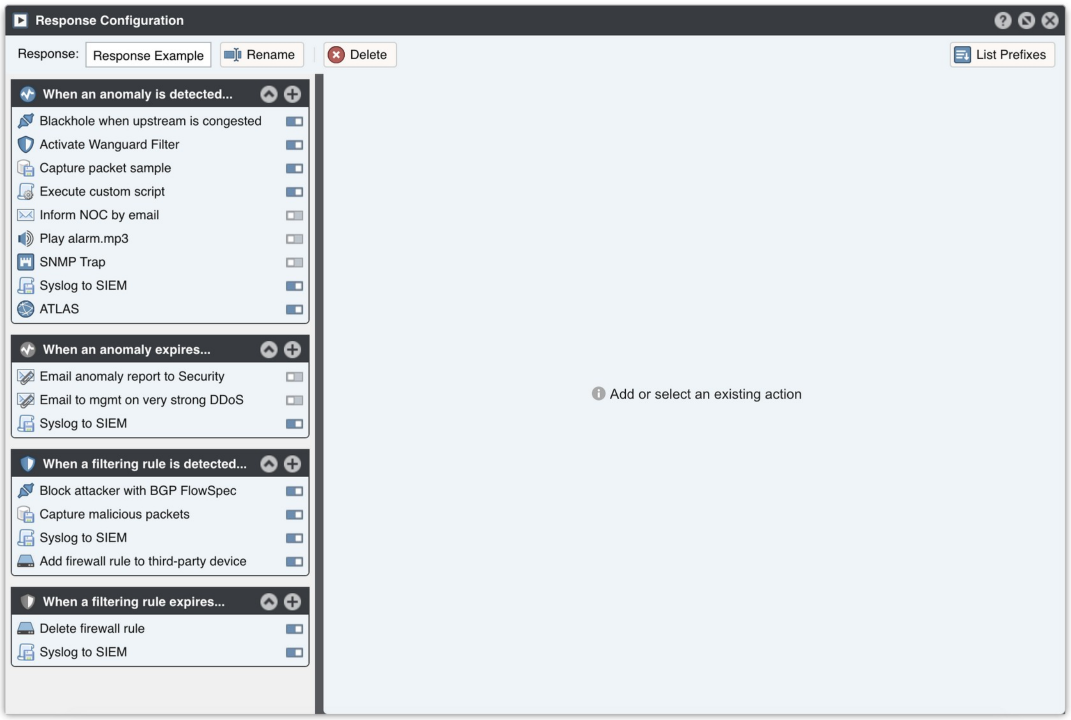
- **Enabled** – Check to allow Wanguard Filter to detect the selected filtering rule
- **Filtering Rule** – Describes the filtering rule
- **Priority** – By double-clicking the cell, you can change the order in which filtering rules are applied. The default settings prioritize filtering rules that match the most specific malicious traffic: source IP, source TCP port, source UDP port. You can disable filtering rules such as destination IP/port to prevent service interruption at the risk of allowing the malicious traffic to pass through when it uses randomized packets
- **Severity** – By double-clicking the cell you can change the minimum severity of the filtering rule. A value of 1 enables the filtering rule when the matched traffic is above the anomaly threshold. To enable the filtering rule only when the matched traffic is double the rate of the anomaly threshold, set it to 2. To enable the filtering rule when the anomaly threshold is matched by half of traffic, set it to 0.5
- **Timeout** – When set to 0, the filtering rule remains active for as long as the anomaly is active. Enter a non-zero value for the filtering rule to expire only after the entered amount of seconds
- **OSI Layer** – Shows the OSI layer where the filtering rule detection is performed; for informational purposes only
- **Compatibility** – Displays whether the filtering rule can be detected and applied by Packet Filter, Flow Filter, BGP Flowspec or Dataplane Firewall.

Configuration » Network & Policy » Response

Responses provide a powerful way to automate and extend the system's reaction to the anomalies detected by Sensor, and to the filtering rules identified by Filter.

To add a new Response, go to Configuration » Network & Policy » [+] and select [Response].

[**List Prefixes**] generates a list with IP classes configured to use the selected Response.


Response Configuration
Response: Response Example
Rename
Delete
List Prefixes
When an anomaly is detected...
Blackhole when upstream is congested
Activate Wanguard Filter
Capture packet sample
Execute custom script
Inform NOC by email
Play alarm.mp3
SNMP Trap
Syslog to SIEM
ATLAS
When an anomaly expires...
Email anomaly report to Security
Email to mgmt on very strong DDoS
Syslog to SIEM
When a filtering rule is detected...
Block attacker with BGP FlowSpec
Capture malicious packets
Syslog to SIEM
Add firewall rule to third-party device
When a filtering rule expires...
Delete firewall rule
Syslog to SIEM
Add or select an existing action

When invoked by a Sensor or Filter, the Response runs the **actions** it contains. These "actions" are built-in modules that provide means to execute commands, send notifications and BGP routing updates, write logs, etc.

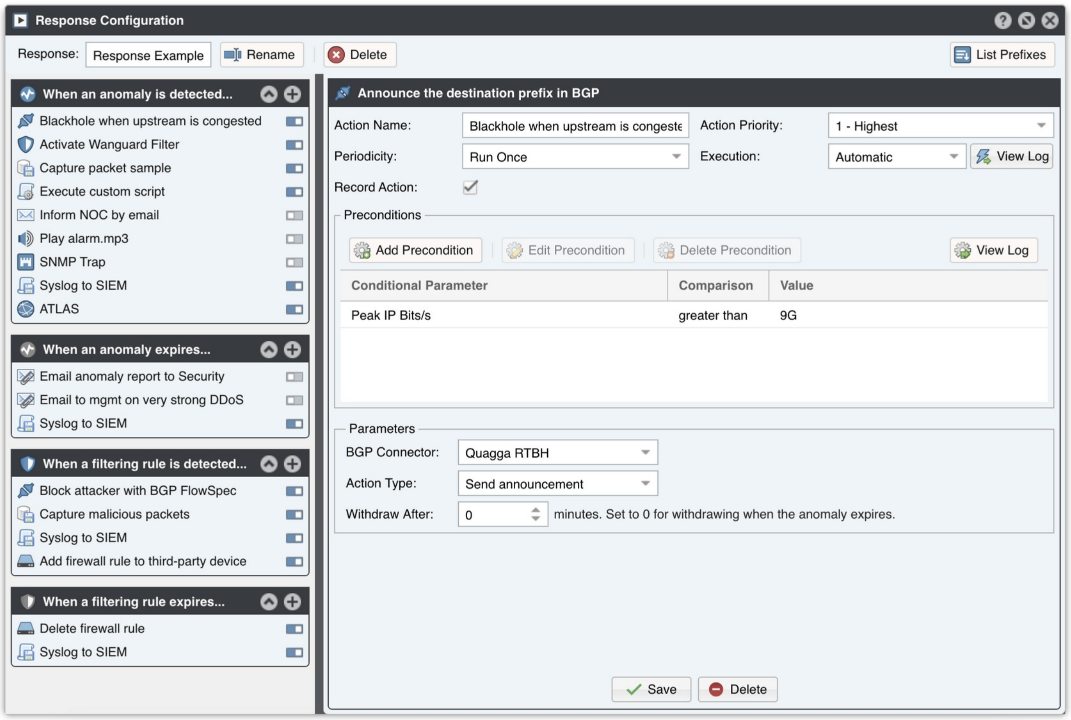
There are two types of actions:

- **Anomaly Actions** – These are executed by Sensor for each traffic anomaly immediately after detection, while it is still detected, or when it expires
- **Filtering Rule Actions** – These are executed by Filter for each filtering rule immediately after detection, while it is still detected, and when it expires. Filtering rules expose malicious packets that share some common OSI layer 3-7 fields (attacker IPs, TCP/UDP ports, packet lengths, protocols, TTLs, content, etc.)

To add an action, click the [+] button on the title bar of the relevant panel from the left side of the window. To view, edit, delete or rename an action, select the action name.

To enable or disable an action, click the play/stop button next to the action name.

Each action configuration panel contains action-specific fields. The following fields are always present:



Response Configuration

Response: Response Example | Rename | Delete | List Prefixes

When an anomaly is detected...
- Blackhole when upstream is congested
- Activate Wanguard Filter
- Capture packet sample
- Execute custom script
- Inform NOC by email
- Play alarm.mp3
- SNMP Trap
- Syslog to SIEM
- ATLAS

When an anomaly expires...
- Email anomaly report to Security
- Email to mgmt on very strong DDoS
- Syslog to SIEM

When a filtering rule is detected...
- Block attacker with BGP FlowSpec
- Capture malicious packets
- Syslog to SIEM
- Add firewall rule to third-party device

When a filtering rule expires...
- Delete firewall rule
- Syslog to SIEM

Announce the destination prefix in BGP

Action Name: Blackhole when upstream is congeste
Action Priority: 1 - Highest
Periodicity: Run Once
Execution: Automatic
Record Action: ✓

Preconditions

Conditional Parameter	Comparison	Value
Peak IP Bits/s	greater than	9G

Parameters

BGP Connector: Quagga RTBH
Action Type: Send announcement
Withdraw After: 0 minutes. Set to 0 for withdrawing when the anomaly expires.

- ***Action Name*** – Short description of the action
- ***Action Priority*** – Select the order of execution relative to the other actions defined in the same panel. Lower numerical values correspond to increased priority
- ***Periodicity*** – Actions can be executed once or periodically. The frequency of execution is 5 seconds for Packet Sensor, Packet Filter, Sensor Cluster and Filter Cluster, or 5-60 seconds for Flow Sensor, depending upon its Granularity parameter
- ***Execution*** – Actions can be executed either automatically without end-user intervention, or manually by an operator or administrator that clicks the lightning icon in Reports » Tools » Anomalies » Active Anomalies » Actions
- ***Record Action*** – When enabled, the name of the action is recorded and displayed in anomaly reports
- ***Preconditions*** – Preconditions are rules that can deny execution of actions. An action is executed only when each precondition is evaluated as true, or when the list of preconditions is empty.

  Each precondition is composed from a **conditional parameter** (listed in **Appendix 5** on page 128), a comparison function, and a user-defined value. Conditional parameters are linked to internal variables whose values are constantly updated by Sensors and Filters.

  Tip: To combine conditional parameters in complex ways (e.g. mix logical disjunction and logical conjunction), write a custom script that uses the conditional parameter named "Custom Script Return Value" together with dynamic parameters passed as arguments

Dynamic parameters are parameters (variables) defined within curly brackets "{ and }", used as parameters or script arguments for most Response actions. Almost every conditional parameter has a corresponding dynamic parameter. All dynamic parameters are listed in **Appendix 5** on page 128.

Extending the Built-in Actions

By adding the Response action named “Execute a command or script with dynamic parameters as arguments” you can easily extend the number of actions executed during attacks and during the detection of filtering rules.

Most data about about the anomaly / filtering rule can be passed to your script as arguments (the full list is listed in **Appendix 5** on page 128). For example, when the script listed below is called with: “/path/to/script/test.sh {anomaly} {ip} {sensor} {latest_anomaly_bps_kilo}”, the anomaly number, attacked IP, detecting Sensor, and current kbps/s value will be written to a temporary file.

```
#!/bin/sh
echo "Anomaly: $1, IP: $2, Sensor: $3, Kbits/s: $4" >> /tmp/test.txt
```

To access data not related to the current anomaly / filtering rule, or to automate the actions from Reports » Tools, call the REST API from within your script. The REST API is documented at *http://<console_ip>/wanguard-api-ui*

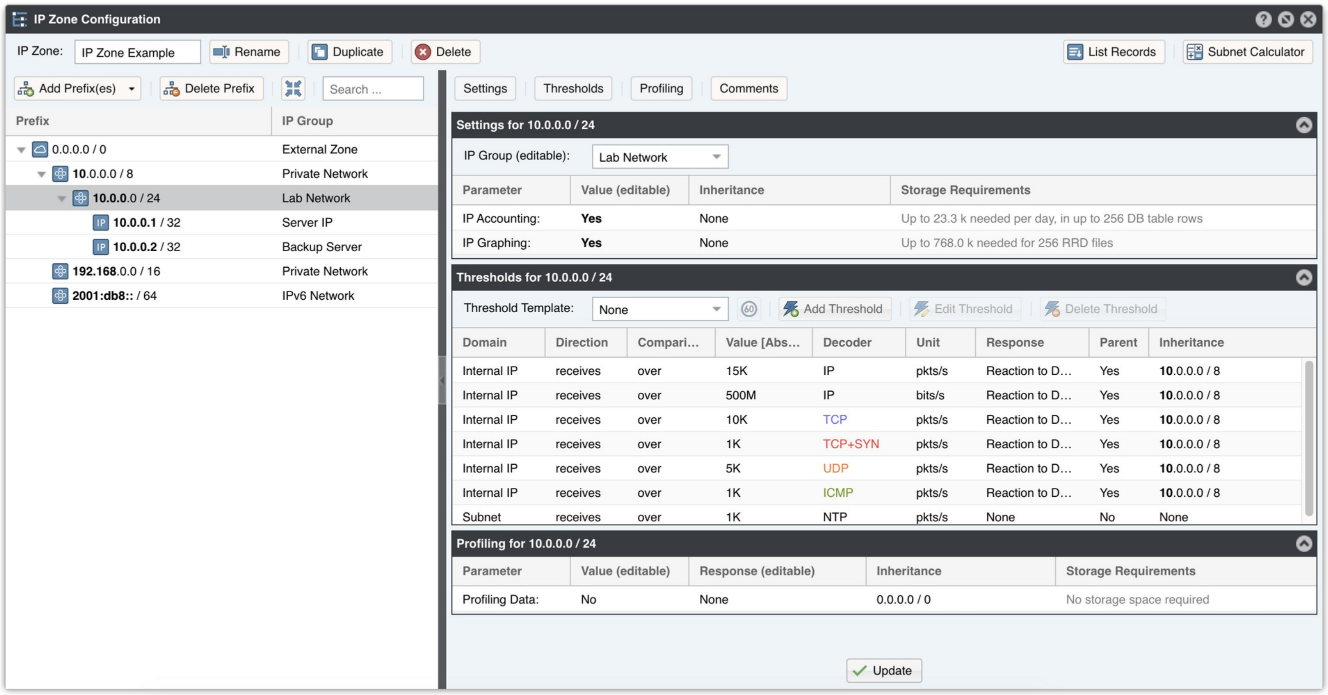
All custom scripts/commands are executed on the detecting Sensor’s server for anomalies and/or on the detecting Filter’s server for filtering rules. When using a custom script, make sure that it can be accessed and executed by the system account named “andrisoft” (e.g. by moving it to /opt/andrisoft/bin). You can check if there are permission-related issues by executing the script manually with “sudo -u andrisoft /path/to/script”.

Configuration » Network & Policy » IP Zone

IP Zones are hierarchical, tree-like data structures used by Sensor to extract per-subnet settings and to learn the protected network's boundaries.

In most configurations, you will have to add your IP blocks to the IP Zones listed in Configuration » Network & Policy. There are several ways to add prefixes (IPs/IP blocks/subnets/ranges): from the web interface, via the REST API by accessing *http://<console_ip>/wanguard-api-ui*, or by executing the command *php /opt/andrisoft/api/cli_api.php* on the Console server.

To add a new IP Zone, go to Configuration » Network & Policy » [+] and select [IP Zone]. You only need more than one IP Zone when you want to use different per-subnet settings for different Sensors. If this is the case, it may be easier to open an existing IP Zone that already includes your IP address ranges, and duplicate it by pressing the [**Duplicate**] button.



Prefix	IP Group
0.0.0.0 / 0	External Zone
10.0.0.0 / 8	Private Network
10.0.0.0 / 24	Lab Network
10.0.0.1 / 32	Server IP
10.0.0.2 / 32	Backup Server
192.168.0.0 / 16	Private Network
2001:db8:: / 64	IPv6 Network

Settings for 10.0.0.0 / 24

IP Group (editable): Lab Network

Parameter	Value (editable)	Inheritance	Storage Requirements
IP Accounting:	Yes	None	Up to 23.3 k needed per day, in up to 256 DB table rows
IP Graphing:	Yes	None	Up to 768.0 k needed for 256 RRD files

Thresholds for 10.0.0.0 / 24

Threshold Template: None

Add Threshold · Edit Threshold · Delete Threshold

Domain	Direction	Compari...	Value [Abs...	Decoder	Unit	Response	Parent	Inheritance
Internal IP	receives	over	15K	IP	pkts/s	Reaction to D...	Yes	10.0.0.0 / 8
Internal IP	receives	over	500M	IP	bits/s	Reaction to D...	Yes	10.0.0.0 / 8
Internal IP	receives	over	10K	TCP	pkts/s	Reaction to D...	Yes	10.0.0.0 / 8
Internal IP	receives	over	1K	TCP+SYN	pkts/s	Reaction to D...	Yes	10.0.0.0 / 8
Internal IP	receives	over	5K	UDP	pkts/s	Reaction to D...	Yes	10.0.0.0 / 8
Internal IP	receives	over	1K	ICMP	pkts/s	Reaction to D...	Yes	10.0.0.0 / 8
Subnet	receives	over	1K	NTP	pkts/s	None	No	None

Profiling for 10.0.0.0 / 24

Parameter	Value (editable)	Response (editable)	Inheritance	Storage Requirements
Profiling Data:	No	None	0.0.0.0 / 0	No storage space required

The IP Zone Configuration window is divided into two vertical sections. The buttons that manage prefixes are located in the upper part of the left section. When a new prefix is added the tree below automatically updates itself. The section on the right contains panels with user-provided settings for the selected prefix.

To enter IP addresses or IP blocks, use the CIDR notation. To enter individual hosts in IP Zones, use the /32 CIDR mask for IPv4 and /128 for IPv6. For more information about the CIDR notation consult Appendix 1 on page 105.

Every IP Zone contains the network 0.0.0.0/0. Because it’s CIDR mask is /0, this “supernet” includes all IP addresses available for IPv4 and IPv6. For an easier configuration, every new prefix that you define inherits by default the properties of the most-specific (having the biggest CIDR mask) IP class that includes it.

The **IP Settings** panel from the section on the right provides the following parameters:

- **IP Group** – Set a short description of the selected prefix, or the name of the customer that uses it. When you set the same IP group on multiple prefixes you will be able to generate aggregated traffic reports. This combo box is editable
- **IP Graphing** – Set to "Yes" to permit the collection of graph data for every IP contained in the selected prefix. The **Graph IP Sweeps** option from Configuration » General Settings » Graphs & Storage can be used to prevent generating graph data for IPs that only receive traffic without sending traffic in return. IP Graphing is always enabled for the subnets explicitly defined in the IP Zone. Do not enable this option on many/large subnets without a performance impact assessment
- **IP Accounting** – Set to "Yes" for the Sensor to generate daily accounting data for each IP contained in the selected prefix. IP Accounting is always enabled for the subnets explicitly defined in the IP Zone. Do not enable on many/large subnets without a performance impact assessment

The **Storage Requirements** column indicates the disk space needed by each Packet Sensor and Flow Sensor interface to store the generated data. Enabling IP graphing and IP accounting for very large prefixes (e.g. 0.0.0.0/0) might generate data that could overload the Console server and fill the disk space. The storage requirements for IP graph data is possible to estimate only for RRD files. For InfluxDB this is not possible.

The **Comments** panel allows you to enter a comment for the selected prefix. It is not visible elsewhere.

Traffic Thresholds

You can define traffic threshold rules by adding them to the **Thresholds** panel in the IP Zone Configuration window. To ease the addition of identical thresholds on multiple prefixes, go to Configuration » Network & Policy » [+] and select [Threshold Template].

Each threshold rule contains the following metrics:

- **Domain** – Sensors can detect anomalies to/from an internal IP contained in the selected subnet or to/from the subnet taken as a whole. If the selected subnet is 0.0.0.0/0 then a third option is possible, which allows detection anomalies to/from external IPs (for this third option to work, the Stats Engine parameter from the Sensor configuration must be set accordingly)
- **Direction** – The direction of traffic can be "receives" for the inbound traffic received by the prefix, or "sends" for the outbound traffic sent by the prefix
- **Comparison** – Select "over" to detect volumetric anomalies (e.g. DrDoS, DDoS) or "under" to detect a gap in traffic
- **Value** – The threshold value can be entered as an absolute number, or as a percentage of the total traffic matched by selected decoder per Sensor interface. Absolute values can be multiples of 1000 with K (kilo) appended, multiples of 1 million with M (mega) appended, or multiples of 1 billion with G (giga) appended
- **Decoder** – Select one of the decoders enabled in Configuration » General Settings » Anomaly Detection (see page 28)
- **Unit** – DDoS attacks usually reach a very high number of packets per second, so the "pkts/s" option is the best way to detect them. For bandwidth-related anomalies, select "bits/s"
- **Response** – Select a previously defined Response, or select "None" to have no reaction to anomalies other than displaying them in Reports » Tools » Anomalies » Active Anomalies

- **Parent** – Select "Yes" if more specific prefixes should inherit the threshold. You can cancel inherited thresholds by defining a similar threshold with "Unlimited" selected in the Value field
- **Inheritance** – Displays the parent prefix when the rule is inherited from a less specific prefix

Adding a threshold rule on 0.0.0.0/0 that reads, "Internal IP receives over 5% TCP+SYN pkts/s" catches port scans and all significant SYN attacks towards any IP address belonging to your network. A threshold rule on 0.0.0.0/0 that reads, "Subnet sends under 1 IP bits/s" executes the Response when the link goes down.

Best practices for setting up traffic thresholds

✔ TCP+SYN thresholds on IPs should be configured to low values, usually at around 500-1000 packets/s. TCP uses packets with the SYN flag set only for establishing new TCP connections, and few services (e.g. very high volume websites) are able to handle more than 1000 new connections every second. SYN packets are frequently used for flooding

✔ TCP bits/s thresholds should be configured to your maximum bandwidth level per IP. TCP packets carry on average around 500 bytes of data. Setting a threshold of 15k TCP packets/s should be enough for medium-sized networks

✔ ICMP thresholds should be configured to very low levels, 50-100 packets/s. ICMP is frequently used for flooding, while legitimate ICMP traffic is never above a few packets/s

✔ UDP traffic usually exhibits high packets/s and low bits/s values, so you can configure low values for bits/s. Setting UDP packets/s thresholds at around 15k/s per destination should not generate false positives while catching all significant UDP floods. UDP is also frequently used for flooding. A special attention must be paid lately to the QUIC protocol which encapsulates high-bandwidth HTTP traffic inside UDP packets

✔ OTHER decoder matches all non-TCP, non-UDP and non-ICMP traffic. You can configure thresholds for OTHER if you have non-standard applications in your network. More than 90% of Internet traffic is either TCP or UDP

✔ Enable additional decoders, such as HTTP, MAIL, NTP, etc., to be able to configure thresholds for specific services and servers

✔ Configure illegal IP address ranges that should never be seen in normal traffic (unallocated IP addresses or parts of your internal IP address range that are unoccupied). Then, add small thresholds to these, to catch malicious activities such as scans and worms

✔ If you open an IP Zone and select 0.0.0.0/0 you will be able to configure thresholds for external IPs (IPs not belonging to your network). This is useful to catch external IPs that scan your network with very few packets sent to each of your IPs

Adding similar threshold rules for the same prefix is not allowed, even when the rules have different values or Responses. To execute different actions for different threshold values, define only the smallest threshold value in IP Zone, and then use preconditions inside the Response. For example, if you want to activate Wanguard Filter for UDP attacks stronger than 100 Mbps but you also want to null-route them in BGP when they reach 1 Gbps, add only the "Internal IP receives over 100M UDP bits/s" rule. Then, inside the Response add two actions: one that activates Filter without Preconditions, and another that executes a BGP announcement with the Precondition "Peak Value" "over" "1G".

Traffic Profiling

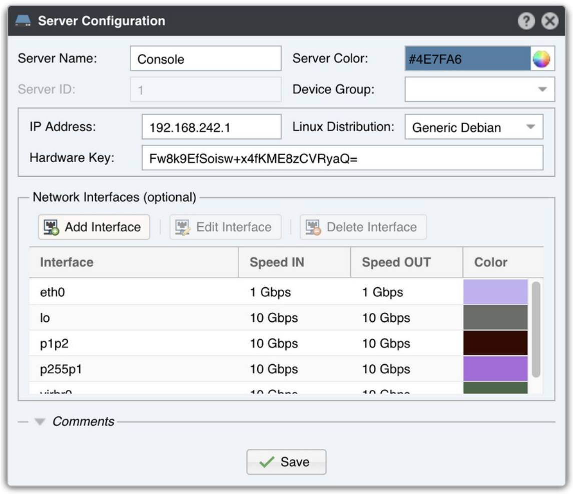
The **Profile Anomalies** panel contains the Profiling Data parameter, which manages the detection of traffic anomalies by profiling traffic behavior:

- *Inherit* – The value is inherited from the parent prefix
- *No* – Do not generate profiling data for the selected prefix
- *Subnet* – Generate profiling data for all traffic received by the prefix as a whole
- *IPs* – Use carefully as it will generate profiling data for every IP contained in the prefix. Enabling this option is not recommended for large subnets because it can overwhelm the I/O of the server, and potentially generate false positives because the traffic of single IPs is not always predictable
- *Subnet + IPs* – Activate both options from above

Configuration » Servers

Any server running a Wanguard component must be added under Configuration » Servers. The Console server is automatically added during installation.

To add a new server, click the [+] button from the title bar of the Configuration » Servers panel. To change the configuration of an existing server, go to Configuration » Servers and click its name.



Server Name:	Console	Server Color:	#4E7FA6
Server ID:	1	Device Group:	
IP Address:	192.168.242.1	Linux Distribution:	Generic Debian
Hardware Key:	Fw8k9EfSoisw+x4fKME8zCVRyaQ=		

Network Interfaces (optional)

Interface	Speed IN	Speed OUT	Color
eth0	1 Gbps	1 Gbps	🟪
lo	10 Gbps	10 Gbps	⬛
p1p2	10 Gbps	10 Gbps	🟫
p255p1	10 Gbps	10 Gbps	🟪

Comments

- **Server Name** – A short name to help you identify the server
- **Server Color** – The color used in graphs for this server. The default color is a random one, which can be changed by clicking the drop-down menu
- **Server ID** – Unique identifier of the server. This id is used when exporting NFS shares
- **Device Group** – Optional description used to group servers by location, role, etc.
- **IP Address** – An IP address defined on the server. Can be public or private, IPv4 or IPv6
- **Linux Distribution** – Select the Linux distribution installed on the server
- **Hardware Key** – Read-only string used for licensing purposes. The hardware key field is updated by the WANsupervisor service when the hardware, IP or hostname changes. If the hardware key is unregistered, send it to sales@andrisoft.com
- **Network Interfaces (optional)** – The WANsupervisor service can monitor packets/s, bits/s, errors and dropped frames for each server interface. The data is available in Reports » Servers » [Server] » Server Graphs » Data Units = Server Interfaces. These stats are provided by the Linux kernel
- **Comments** – These observations are not visible elsewhere

Distributing the Software over Multiple Servers

You can distribute Sensors and Filters over multiple servers for load and geographical distribution, or for high-availability and redundancy:

1. Add the new server in Console, under Configuration » Servers, set the IP and enter a Server Name
2. Install the software on the new server by following the installation instructions from the link contained in the response mail to the evaluation request
3. When executing */opt/andrisoft/bin/install_supervisor* enter the IP of the Console server and the Console database password
4. Start the WANsupervisor service on the new server
5. Make sure that NTP is running on the server and that the status is OK in Reports » Devices » Overview
6. During the trial period you don't have to register any server. Outside the trial period, you have to register the server's hardware key, which is visible in Configuration » Servers » [New Server] after starting the WANsupervisor service. Hardware registration is free by emailing sales@andrisoft.com
7. Define a new Sensor or Filter and set its Server parameter accordingly
8. Start the new Sensor or Filter from Configuration » Components
9. Watch the event log to see if there are any errors or warnings

Server Troubleshooting

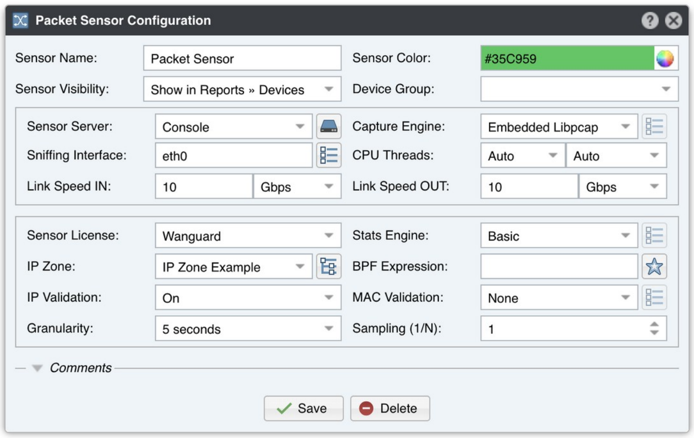
- ✔ For the server to be operational, make sure it always runs the WANsupervisor service and that its clock is synchronized with NTP. You can verify the operational status of each server and component in Reports » Devices » Overview » Servers
- ✔ The WANsupervisor service stops when the MySQL/MariaDB service running on the Console server is restarted or unavailable even for a short amount of time (e.g. during a network outage). In this case, either restart WANsupervisor manually or use automated tools such as systemd, monitd or similar
- ✔ You can discover performance-related issues by monitoring Reports » Server » [Server] » Server Graphs and Reports » Server » [Server] » Server Events
- ✔ If the DB crashes (usually due to power failures) execute */opt/andrisoft/bin/WANmaintenance repair_db*

Configuration » Components » Packet Sensor

In switched networks, only the packets for a specific device reach the device's network card. If the server running the **Packet Sensor** is not deployed in-line in the main data path, a network TAP, or a switch/router that offers a “monitoring port” or “mirroring port” must be used. In this case, the network device sends copies of data packets traveling through selected ports or VLANs to the monitoring port. Packet Sensor inspects every packet it receives and conducts packet-based traffic analysis. The advantages and disadvantages of packet-based traffic monitoring are listed on page 8.

For instructions on how to configure switches or routers for port mirroring, consult their documentation.

To add a Packet Sensor, click the [+] button from the title bar of the Configuration » Components panel. To modify an existing Packet Sensor, go to Configuration » Components and click its name.


Packet Sensor Configuration

Sensor Name:	Packet Sensor	Sensor Color:	#35C959
Sensor Visibility:	Show in Reports » Devices	Device Group:	
Sensor Server:	Console	Capture Engine:	Embedded Libpcap
Sniffing Interface:	eth0	CPU Threads:	Auto / Auto
Link Speed IN:	10 Gbps	Link Speed OUT:	10 Gbps
Sensor License:	Wanguard	Stats Engine:	Basic
IP Zone:	IP Zone Example	BPF Expression:	
IP Validation:	On	MAC Validation:	None
Granularity:	5 seconds	Sampling (1/N):	1

- **Sensor Name** – A short name to help you identify the Packet Sensor
- **Sensor Color** – The color used in graphs for the Packet Sensor. The default color is a random one, which can be changed by clicking the drop-down menu
- **Sensor Visibility** – Toggles the listing inside Reports » Devices
- **Device Group** – Optional parameter used for grouping up components (e.g. by location or role). It can be used to restrict the access of Guest accounts
- **Sensor Server** – The server that runs the Packet Sensor. The configuration of servers is described on page 39
- **Capture Engine** – Select the preferred packet capturing engine. LibPcap requires no additional setup but it is too slow for multi-gigabit sniffing and it does not run on multiple threads. Netmap and PF_RING are much faster but both require the installation of additional kernel modules. DPDK provides the fastest packet capturing engine and allows packet forwarding but it is very complicated to configure.
    - *Embedded LibPcap* – Select to use the built-in LibPcap 1.8.1 library
    - *System LibPcap* – Select to use the LibPcap library installed by the Linux distribution-
    - *Netmap* – Select to use the Netmap framework to speed up packet processing

  - *PF_RING* – Select to use the PF_RING framework to speed up packet processing. Click the button on the right for PF_RING-specific settings
  - *DPDK* – Select to use the DPDK framework, then click the button on the right of the Capture Engine field to configure DPDK-specific parameters as described in Appendix 6 in page 134
- **Sniffing Interface** – The network interface(s) listened by the Packet Sensor. If the server running the Packet Sensor is deployed in-line, then this field must contain the network interface that receives the traffic entering your network. The PF_RING framework allows listening to multiple physical interfaces simultaneously when the interfaces are entered separated by semicolon ";"
- **CPU Threads** – Packet Sensor can run multi-threaded on a given set of CPU cores. Each thread increases the RAM usage. On most systems, activating more than 6 CPU threads hurts performance
- **Link Speed IN / OUT** – Enter the speed (bandwidth, capacity) of the monitored link. The values are used for percentage-based reports and percentage-based bits/s thresholds
- **Sensor License** – The license used by the Packet Sensor. Wanguard provides all features; Wansight does not provide traffic anomaly detection and reaction
- **Stats Engine** – Collects traffic tops and AS graphs:
  - *Basic* – Enables tops for Internal IPs, IP protocols, versions and TCP/UDP ports. It is the recommended value because it adds a very small performance penalty
  - *Extended* – Enables all tops from *Basic* as well as tops for external IPs (IPs not included in the IP Zone). It adds performance penalty of over 20%, especially during spoofed attacks. Permits the detection of threshold violations for external IPs
  - *Full* – Enables all tops from *Extended* as well as tops and graphs for autonomous systems. It adds a performance penalty of over 20%, especially during spoofed attacks. Permits the detection of threshold violations for external IPs
- **Stats Engine Options** – When Stats Engine is set to Full you can click the button next to it. To enable Transit AS tops and graphs, enter the path to an existing **BGP Dump File** exported by BGPd in MTR format, and the IPv4 and optionally IPv6 address of the BGP router
- **IP Zone** – Packet Sensor needs an IP Zone from which to learn about your network's boundaries and to extract per-subnet settings. IP Zones are described in the "IP Zone" chapter on page 35
- **BPF Expression** – You can filter the type of traffic the Packet Sensor receives using a tcpdump-style syntax
- **IP Validation** – This option is the most frequently-used way to distinguish the direction of the packets:
  - *Off* – Packet Sensor analyzes all traffic and uses MAC Validation to identify the direction of traffic
  - *On* – Packet Sensor analyzes the traffic that has the source and/or the destination IP in the selected IP Zone
  - *Strict* – Packet Sensor analyzes the traffic that has either the source or the destination IP in the selected IP Zone
  - *Exclusive* – Packet Sensor analyzes the traffic that has the destination IP in the selected IP Zone, but not the source IP
- **MAC Validation/Options** – This option can be used to distinguish the direction of the packets or to ignore unwanted OSI Layer 2 traffic:
  - *None* – Packet Sensor analyzes all traffic and uses IP Validation to identify the direction of traffic
  - *Upstream MAC* – MAC validation is active and the MAC Address belongs to the upstream router

   - *Downstream MAC* – MAC validation is active and the MAC Address belongs to the downstream router

     The MAC Address must be written using the Linux convention – six groups of two hexadecimal values separated by colons (`:`)

- **Granularity** – Interval between successive updates for traffic parameters and anomalies. A granularity of 1 second ensures detection of anomalies in under one second at the expense of the SQL server's load
- **Sampling (1/N)** – Contains the packet sampling rate. On most systems, the correct value is 1
- **Comments** – Comments about the Packet Sensor can be saved here. They are not visible elsewhere

To start the Packet Sensor, click the small button displayed next to its name in Configuration » Components. Ensure that the Packet Sensor starts correctly by watching the event log (details on page 69).

If the Packet Sensor starts without errors, but you can't see any data collected by it in Reports » Devices » Overview, follow the troubleshooting steps listed below.

Packet Sensor Troubleshooting

- ✔ Look for warnings or errors produced by the Packet Sensor in the event log (details on page 69)
- ✔ Ensure that you have correctly configured the Packet Sensor. Each configuration field is described in this chapter
- ✔ The event log error "*License key not compatible with the existing server"* can be fixed by sending the string from Configuration » Servers » [Packet Sensor server] » Hardware Key to sales@andrisoft.com
- ✔ Make sure that the sniffing interface is up:

  ```
  ip link show <interface>
  ```
- ✔ Ensure that you have correctly configured the switch/TAP to send packets to the server on the configured interface
- ✔ Verify whether the server is receiving packets via the configured interface:

  ```
  tcpdump -i <interface_usually_eth1_or_p1p2> -n -c 100
  ```
- ✔ When **IP Validation** is not disabled, make sure that the selected IP Zone contains all your subnets
- ✔ If the CPU usage of the Packet Sensor is too high, set the **Stats Engine** parameter to "Basic", install PF_RING, Netmap or DPDK to enable multi-threading, or use a network adapter that allows distributing Packet Sensors over multiple CPU cores
- ✔ To troubleshoot Sensor graph or IP graph issues, follow the Graphs Troubleshooting guide on page 25
- ✔ For PF_RING-related issues, contact ntop.org. To increase the maximum number of PF_RING programs from 64 to 256, increase the MAX_NUM_RING_SOCKETS defined in kernel/linux/pf_ring.h and recompile the pf_ring kernel module
- ✔ The system process responsible for capturing packets is called WANtrafficlogger. There will be as many processes active as the number of packet dumps active in Reports » Tools » Packets
- ✔ Make sure you are running the latest version of the software by checking Help » Software Updates

Packet Sensor Optimization Steps for Intel 82599

To distribute the packet-processing tasks of the Packet Sensor over multiple CPU cores when using an adapter with the Intel 82599 chipset (Intel X520, Intel X540, HP X560, etc.):

- ✔ Follow the documentation and optimization guides provided by the network adapter vendor
- ✔ Install PF_RING and switch to the PF_RING-aware ixgbe driver
- ✔ See the number of RSS queues allocated by the ixgbe driver by executing dmesg, or by listing /var/log/messages or /var/log/syslog. By default, the number of RSS queues is equal to the number of CPU cores when hyper-threading is off, or double the number of CPU cores when hyper-threading is on. You can set the number of RSS queues manually, by loading ixgbe.ko with the RSS=<number> option
- ✔ Enable multithreading in the Packet Sensor configuration or define multiple Packet Sensors, each listening to ethX@queue_id or ethX@queue_range and add them to a Sensor Cluster to have a unified reporting and anomaly detection domain. No additional licensing is needed because all Packet Sensors defined to listen to a single interface use a single Sensor license

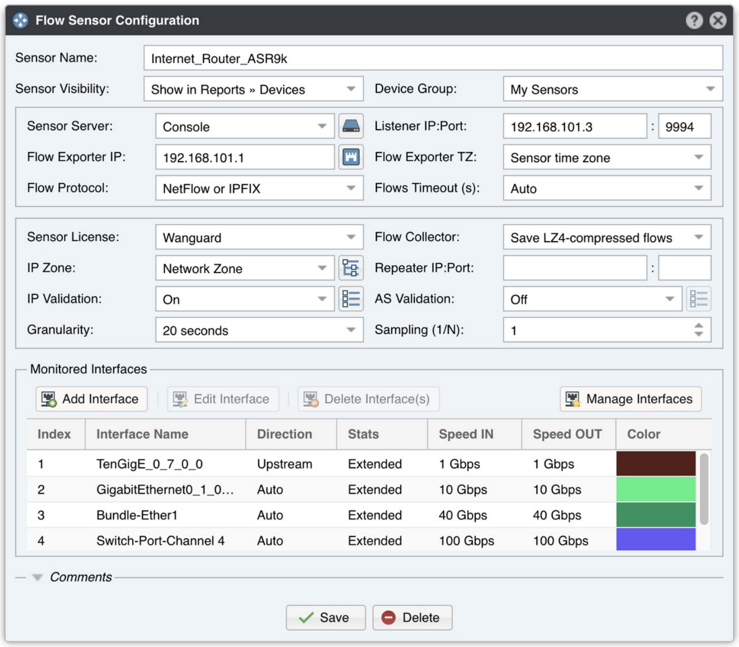
On a quad-core CPU with multithreading, the ixgbe driver allocates 8 RSS queues. In this case, if you define a Packet Sensor for ethX@0-3 and another one for ethX@4-7, the packet-processing task will be distributed over 2 CPU cores. PF_RING exposes up to 32 RSS queues.

Configuration » Components » Flow Sensor

Many routers and switches can collect IP traffic statistics and periodically export them in form of flow records to **Flow Sensor**. Since the flow protocol already performs pre-aggregation of traffic data, the flow data sent to Flow Sensor is much smaller than the monitored traffic, and this makes the Flow Sensor a good option for monitoring remote or high-traffic networks. The advantages and disadvantages of flow-based monitoring are listed on page 8.

For detailed instructions on how to enable NetFlow, sFlow or IPFIX on your network device, please consult its documentation. Appendix 2 on page 106 lists some configuration examples for a few Cisco IOS, CatOS, and Juniper devices.

To add a Flow Sensor, click the [+] button from the title bar of the Configuration » Components panel. To modify an existing Flow Sensor, go to Configuration » Components and click its name.



Sensor Name: Internet_Router_ASR9k
Sensor Visibility: Show in Reports » Devices
Device Group: My Sensors
Sensor Server: Console
Listener IP:Port: 192.168.101.3 : 9994
Flow Exporter IP: 192.168.101.1
Flow Exporter TZ: Sensor time zone
Flow Protocol: NetFlow or IPFIX
Flows Timeout (s): Auto
Sensor License: Wanguard
Flow Collector: Save LZ4-compressed flows
IP Zone: Network Zone
Repeater IP:Port: :
IP Validation: On
AS Validation: Off
Granularity: 20 seconds
Sampling (1/N): 1

Monitored Interfaces

Index	Interface Name	Direction	Stats	Speed IN	Speed OUT	Color
1	TenGigE_0_7_0_0	Upstream	Extended	1 Gbps	1 Gbps	🟫
2	GigabitEthernet0_1_0…	Auto	Extended	10 Gbps	10 Gbps	🟩
3	Bundle-Ether1	Auto	Extended	40 Gbps	40 Gbps	🟩
4	Switch-Port-Channel 4	Auto	Extended	100 Gbps	100 Gbps	🟦

- **Sensor Name** – A short name to help you identify the Flow Sensor
- **Reports Visibility** – Toggles the visibility inside Reports » Devices
- **Device Group** – Optional description used used to group up components (e.g. by location or role). It can be used to restrict the access of Guest accounts
- **Sensor Server** – The server that runs the Flow Sensor. The configuration of servers is described on page 39
- **Listener IP:Port** – The IP address (IPv4 or IPv6) of the network interface that receives the flow packets, and the destination port
- **Flow Exporter IP** – IP address of the flow exporter (router, switch, probe). Usually, it is the loopback address of the router. For sFlow exporters, enter the IP that sends flow packets, not the Agent IP
- **SNMP Settings** – Click the button on the right side of the Flow Exporter IP field. You must enable SNMP

on the flow exporter to allow Console to automatically extract interface information. When SNMP settings are not configured, you must manually enter the SNMP index, speed, etc. for each interface

- **Flow Exporter TZ** – Set the time offset between the time zone (TZ) of the Flow Sensor server and the time zone of the flow exporter. Running NTP on both devices to keep their clocks synchronized is a critical requirement
- **Flow Protocol** – Flow protocol used by the flow exporter: NetFlow, IPFIX or sFlow
- **Flows Timeout (s)** – Some flow exporters (e.g. Juniper MX) maintain the start time of flows that were already exported. If this is the case then you need to set here the same flow active/inactive timeout value (in seconds) as the one defined in the flow exporter's configuration
- **Sensor License** – The license type allocated to the Flow Sensor. Wanguard provides all features; Wansight does not provide traffic anomaly detection and reaction
- **Flow Collector** – When enabled, flow data is stored in a space-efficient binary format. LZO is the fastest. BZ2 offers the best compression rate but it’s 30 times slower than LZO. LZ4 offers a compromise between speed and efficiency. Flow records can be queried in Reports » Tools » Flows
- **IP Zone** – Flow Sensor needs an IP Zone from which to learn the monitored network's boundaries and to extract per-subnet settings. For more information about IP Zones consult the dedicated chapter from page 35
- **Repeater IP:Port** – An embedded packet repeater can send all incoming flows to another flow collector or host. To use this optional feature enter the IP of the other flow collector and a port of your choice
- **IP Validation** – This option can be used to distinguish the direction of traffic or to ignore certain flows:
  - *Off* – Flow Sensor examines all flows and the traffic direction is established by the interface
  - *On* – Flow Sensor examines the flows that have the source IP and/or the destination IP inside the selected IP Zone. This is the recommended setting for most setups
  - *Strict* – Flow Sensor examines the flows that have either the source IP or the destination IP inside the IP Zone
  - *Exclusive* – Flow Sensor examines the flows that have the destination IP inside the IP Zone
- **IP Validation Options** – Set the **Log Invalidated Flows** field to *Periodically* if you want to see in the event log the percentage of invalidated flows and 10 flows failing validation, once every 10 ticks
- **AS Validation** – Flows from BGP-enabled routers can contain the source and destination Autonomous System number (ASN). In most configurations if the AS number is set to 0 then the IP address belongs to your network. This rarely-used option is used for establishing traffic direction. AS validation has three choices:
  - *Off* – Disables AS validation
  - *On* – Flow Sensor examines only the flows that have the source ASN and/or the destination ASN inside the local AS list (defined below)
  - *Strict* – Flow Sensor examines only the flows that have either the source ASN or the destination ASN inside the local AS list (defined below)
- **AS Validation Options** – When AS Validation is enabled, you can enter all your AS numbers (separated by space) into the **Local AS List** field. Set the **Log Invalidated Flows** field to *Periodically* if you want to see in the event log the percentage of invalidated flows and 10 flows failing validation, once every 10 ticks
- **Granularity** – Low values increase the accuracy of Sensor graphs, at the expense of increasing the RAM usage

- **Sampling (1/N)** – Enter the sampling rate configured on the flow exporter, or “1” when no sampling rate is configured. For NetFlow v9 and sFlow the value entered here is ignored because the flow protocol automatically adjusts the sampling rate. To force a particular sampling value, enter it as a negative value
- **Monitored Interfaces** – List of interfaces that should be monitored. To avoid producing duplicate flow entries, add only upstream interfaces
  - *SNMP Index* – The interfaces are internally identifiable only by their SNMP indexes. Enter the index manually, or configure SNMP settings
  - *Interface Name* – A short description used to identify the monitored interface. Descriptions longer than 10 characters clutter some reports
  - *Interface Color* – The color used in graphs for the interface. The default color is a random one, which can be changed by clicking the drop-down menu
  - *Traffic Direction* – Direction of traffic entering the interface, relative to your network:
    - “Auto” – When selected, the direction of traffic is established by IP and/or AS Validation alone. This is the recommended setting in most cases
    - “Upstream” – Set for upstream interfaces, e.g. peering interfaces, interfaces connected to the Internet
    - “Downstream” – Set for downstream interfaces, e.g. customer interfaces, interfaces connected to your network
    - “Null” – Traffic to Null interfaces is discarded by the router and should be ignored
  - *Stats Engine* – Collects various traffic tops and AS (Autonomous System) data:
    - “Basic” – Enables tops for Internal IPs, IP protocols, versions and TCP/UDP ports. It adds a very small performance penalty
    - “Extended” (recommended) – Enables all tops from “Basic” as well as tops and graphs for autonomous systems and countries, but slightly increases the CPU usage. When the router does not export AS information in flows (e.g. non-BGP router), Flow Sensor uses an internal GeoIP database to obtain AS data. Live stats for autonomous systems and countries may not be very accurate
    - “Full” – Enables all tops from “Extended” as well as tops for external IPs (IPs not included in the IP Zone), but increases the RAM usage several times over, especially during spoofed attacks. Live stats for autonomous systems and countries are very accurate. Set the value to “Extended”, unless you know what you’re doing. Only this option permits the detection of threshold violations for external IPs
  - *Stats Engine Options* – When Stats Engine is set to “Extended” or “Full”, you can click the button next to it. To enable Transit AS tops and graphs, enter the path to an existing BGP Dump File exported by BGPd in MTR format, and the IPv4 and optionally IPv6 address of the BGP router
  - *Link Speed In & Link Speed Out* – Enter the speed (bandwidth, capacity) of the interface. The values are used for percentage-based reports and percentage-based bits/s thresholds
- **Comments** – Comments about the Flow Sensor can be saved here. These observations are not visible elsewhere

To start the Flow Sensor, click the small button displayed next to its name in Configuration » Components. Ensure that the Flow Sensor starts correctly by watching the event log (details on page 69).

If the Flow Sensor starts without errors, but you can't see any data collected by it in Reports » Devices » Overview after more than 5 minutes, follow the troubleshooting guide below.

Flow Sensor Troubleshooting

- ✔ Look for warnings or errors produced by the Flow Sensor in the event log (details on page 69)
- ✔ Check if you have correctly configured the Flow Sensor. Each configuration parameter is described in the previous section
- ✔ Event log error "*License key not compatible with the existing server"* can be fixed by sending the string from Configuration » Servers » [Flow Sensor server] » Hardware Key to sales@andrisoft.com
- ✔ Ensure that the server is receiving flow packets on the configured **Listener IP:Port**:

  ```
  tcpdump -i <interface_eth0_p1p1_etc> -n -c 100 host <flow_exporter_ip> and udp and
  port <destination_port>
  ```
- ✔ Make sure that the local firewall permits the Flow Sensor to receive flow packets:

  ```
  iptables -L -n -v && iptables -t raw -L -n -v
  ```
- ✔ Ensure that the clocks of both devices are synchronized with NTP. When the devices do not reside in the same time zone, adjust the **Time Settings** parameter accordingly
- ✔ Flow Sensor may crash during spoofed attacks for not having enough RAM when a monitored interface has the *Stats Engine* parameter set to "Full". It is highly recommended to set the **Stats Engine** parameter to "Extended" instead of "Full" on systems with low amounts of RAM
- ✔ When you add interfaces with the **Traffic Direction** parameter set to "Auto", make sure that the IP Zone you have selected contains all your IP blocks because **IP Validation** and/or **AS Validation** will be used to establish traffic direction. To capture a sample of flows failing validation in the event log, set the **Log Invalidated Flows** parameter to "Periodically"
- ✔ In order to provide fast and up-to-date traffic statistics, the Flow Sensor accepts only flows describing traffic from the last 5 minutes. All flows aged and exported with a delay exceeding 300 seconds are ignored, and the event log contains the warning "*Received flow <starting/ending> <X> seconds ago*"

  When the warnings refer to the starting time, make sure that the clocks between the server and the router are synchronized, the flow exporter is properly configured, and the time zone and **Flow Timeout** are correctly set.

  When the warnings refer to the ending time, make sure that the clocks are synchronized, the time zone is correctly set, the flow exporter is properly configured, and the PFC PIC is not overloaded (on Juniper in particular).

  You can double-check whether the time of the Flow Sensor and the start/end time of flows differ by more than 300 seconds. In Reports » Tools » Flows » Flow Records, select any interface of the Flow Sensor, set Output to Debug and generate a listing for the last 5 minutes:

  - Column *Date_flow_received* indicates the time when the Flow Sensor received the flow packet
  - Column *Date_first_seen* indicates the time when the flow started
  - Column *Date_last_seen* indicates the time when the flow ended

  Flow Sensor does not misinterpret the start/end time of flows. A few flow exporters are known to have bugs, limitations or inconsistencies regarding flow aging and stamping flow packets with the correct time. In this case, contact your vendor to make sure that the flow exporter is correctly configured, and it is able to expire flows in under 5 minutes. In some cases, a router reboot fixes the issue.

In some JunOS versions there is a flow export rate limit with a default of 1k pps, which leads to flow aging errors. To raise the limit to 40k pps you need to execute:

```
set forwarding-options sampling instance NETFLOW family inet output inline-jflow
flow-export-rate 40
```

Some Cisco IOS XE devices do not export flows using NetFlow version 5, in under 5 minutes, even when configured to do so. In this case, switch to using Flexible NetFlow

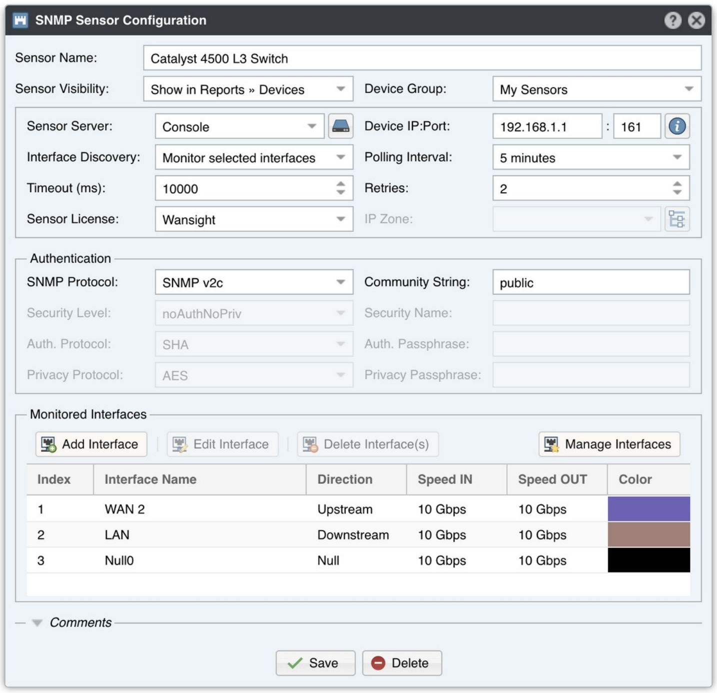
- ✔ Ensure that you have correctly configured the flow exporter to send flows to the server for each of the monitored interfaces. To list all interfaces that send flows, go to Reports » Tools » Flows » Flow Tops, select any Flow Sensor interface, set Output to Debug, set Top Type to Any Interface and generate a top for the last 10 minutes. The column In/Out_If lists the SNMP index of every interface that exports flows, even if it was not configured as a monitored interface in the Flow Sensor configuration
- ✔ If you see statistics for only one traffic direction (inbound or outbound), go to Reports » Tools » Flows » Flow Records, and generate a listing for the last 10 minutes. If all your IPs are listed in a single column, check the flow exporter's configuration and feature list. Not all devices can export flows in both directions (e.g. some Brocade equipment generates only inbound sFlow) or with the same interface SNMP index
- ✔ The traffic readings of the Flow Sensor may differ from the SNMP Sensor or from other SNMP-based monitoring tools. Flow Sensor counts In/Out traffic as traffic entering/exiting the IP Zone (when **IP Validation** is enabled), unlike SNMP tools that count In/Out traffic as traffic entering/exiting the interface. You can double-check the traffic readings of a Flow Sensor by configuring an SNMP Sensor to monitor the same flow exporter (page 50)
- ✔ If the Flow Sensor does not show the correct statistics after upgrading the router's firmware, the SNMP index of the interfaces may have changed. In this case, adjust the SNMP indexes for the monitored interfaces manually, or redefine them
- ✔ If the traffic is too low after upgrading to JunOS 15.1F2 or 16.1R1, execute:

  ```
  set chassis fpc inline-services flow-table-size ipv4-flow-table-size 15
  ```
- ✔ To troubleshoot Sensor graph or IP graph issues, follow the Graphs Troubleshooting guide on page 25
- ✔ Make sure you are running the latest version of the software by checking Help » Software Updates

Configuration » Components » SNMP Sensor

SNMP Sensor monitors the bandwidth usage of routers and switches on a port-by-port basis. SNMP Sensor queries devices (e.g. routers, switches, servers) for the traffic counters of each port with small data packets. These are triggering reply packets from the device. The advantages and disadvantages of monitoring traffic by SNMP are listed on page 8. For detailed instructions on how to enable SNMP on your network device, consult its documentation.

To add an SNMP Sensor click the [+] button from the title bar of the Configuration » Components panel. To modify an existing SNMP Sensor, go to Configuration » Components and click its name.



SNMP Sensor Configuration

Sensor Name:	Catalyst 4500 L3 Switch		
Sensor Visibility:	Show in Reports » Devices	Device Group:	My Sensors
Sensor Server:	Console	Device IP:Port:	192.168.1.1 : 161
Interface Discovery:	Monitor selected interfaces	Polling Interval:	5 minutes
Timeout (ms):	10000	Retries:	2
Sensor License:	Wansight	IP Zone:	

Authentication

SNMP Protocol:	SNMP v2c	Community String:	public
Security Level:	noAuthNoPriv	Security Name:	
Auth. Protocol:	SHA	Auth. Passphrase:	
Privacy Protocol:	AES	Privacy Passphrase:	

Monitored Interfaces

Add Interface · Edit Interface · Delete Interface(s) · Manage Interfaces

Index	Interface Name	Direction	Speed IN	Speed OUT	Color
1	WAN 2	Upstream	10 Gbps	10 Gbps	🟪
2	LAN	Downstream	10 Gbps	10 Gbps	🟫
3	Null0	Null	10 Gbps	10 Gbps	⬛

Comments

Save · Delete

- **Sensor Name** – A short name to help you identify the SNMP Sensor
- **Sensor Visibility** – Toggles the listing inside Reports » Devices
- **Device Group** – Optional description to group up components (e.g. by location or role). It can be used to restrict the access of Guest accounts
- **Sensor Server** – Which server runs the SNMP Sensor. It is recommended to run all SNMP Sensors on the Console server. The configuration of servers is described on page 39
- **Device IP:Port** – Enter the IP address and SNMP port (161 by default) of the networking device
- **Interface Discovery** – Activates or deactivates interface discovery:
    - *Monitor all interfaces* – Select to add all interfaces automatically to the SNMP Sensor. The interface names are based on the **Interface Name** setting available when pressing the [**SNMP Tester & SNMP Object Identifier**] button located next to the **Device IP:Port** field. This is not the recommended option because it clutters the Console

  - *Monitor defined interfaces* – Select to monitor only the interfaces from the Monitored Interfaces grid
- **Polling Interval** – Polling is the process of sending the SNMP request periodically to the device in order to retrieve information. A low polling interval (±1 minute) gives you granular reports but may place an increased load on your server if you poll a large number of interfaces
- **Timeout (ms)** – The timeout value should be at least a little more than double the time it takes for a packet to travel the longest route between devices on your network. The default value is 1000 milliseconds (1 second)
- **Retries** – This value represents the number of times the SNMP Sensor retries a failed SNMP request defined as any SNMP request that does not receive a response within the Timeout (ms) defined above. The default value is 2
- **Sensor License** – License used by the SNMP Sensor. Wanguard provides all features (although severely limited by the SNMP technology); Wansight does not provide traffic anomaly detection and reaction
- **IP Zone** – When a Wanguard license is being used, the SNMP Sensor can check thresholds listed in the selected IP Zone with the following precondition (because SNMP does not provide any information about IPs or protocols):
  - Subnet must be “0.0.0.0/0”
  - Domain must be “subnet”
  - Value must be absolute, not percentage
  - Decoder must be “IP”
- **SNMP Protocol** – Select the SNMP protocol used for authentication:
  - *SNMP v1* – Easy to set up – only requires a plaintext community. Supports only 32-bit counters and it has very little security
  - *SNMP v2c* – Version 2c is identical to version 1, except it adds support for 64-bit counters. This is imperative when monitoring gigabit interfaces. Even a 1Gbps interface can wrap a 32-bit counter in 34 seconds, which means that a 32-bit counter being polled at one-minute intervals is useless. Select this option instead of v1 in most cases
  - *SNMP v3* – Adds security to the 64-bit counters. SNMP version 3 adds both encryption and authentication, which can be used together or separately. Setup is much more complex than just defining a community string
- **Community String** – SNMP v1 and v2c credentials serve as a type of password that is authenticated by confirming a match between the string provided here and the SNMP Community String stored as a MIB object on an SNMP-enabled, managed device
- **Security Level & Name** – SNMP v3-only. SNMP Sensor supports the following set of security levels as defined in the USM MIB (RFC 2574):
  - *noAuthnoPriv* – Communication without authentication and privacy
  - *authNoPriv* – Communication with authentication and without privacy
  - *authPriv* – Communication with authentication and privacy
- **Authentication Protocol & Passphrase** – SNMP v3-only. The protocols used for Authentication are *MD5* and *SHA* (Secure Hash Algorithm)
- **Privacy Protocol & Passphrase** – SNMP v3-only. An indication of whether messages sent on behalf of this user can be protected from disclosure, and if so, the type of privacy protocol which is used. This

option takes the value *DES* (CBC-DES Symmetric Encryption) or *AES* (Advanced Encryption Standard)

- **Monitored Network Interfaces** – The grid must contain the interfaces that should be monitored. To avoid mirrored graphs, add only the upstream interfaces. Settings per interface:
    - *SNMP Index* – The interfaces are identifiable by their unique indexes
    - *Interface Name* – A short description used to identify the monitored interface. Descriptions longer than 10 characters clutter some reports. By default, the auto-filled interface name is retrieved from the ifAlias OID. To change the OID used for the interface name click the [**SNMP Tester & SNMP Object Identifier**] button located next to the **Device IP:Port** field
    - *Interface Color* – Color used in graphs for the interface. The default color is a random one, which can be changed by clicking the drop-down menu
    - *Traffic Direction* – Direction of the traffic entering the interface, from the user's perspective:
        - "Unset" – Traffic entering the interface is considered "downstream"; traffic exiting the interface is considered "upstream"
        - "Upstream" – Set for upstream interfaces, e.g. peering interfaces, interfaces connected to the Internet
        - "Downstream" – Set for downstream interfaces, e.g. customer interfaces, interfaces connected to your network
        - "Null" – Traffic to Null interfaces is ignored
    - *Link Speed In & Link Speed Out* – Enter the speed (bandwidth, capacity) of the interface. The values are used for percentage-based reports and percentage-based bits/s thresholds
- **Comments** – Comments about the SNMP Sensor can be saved here. These observations are not visible elsewhere

To start the SNMP Sensor, click the small button displayed next to its name in Configuration » Components. Ensure that the SNMP Sensor starts correctly by watching the event log (details on page 69).

If the SNMP Sensor starts without errors, but you cannot see any data collected by it in Reports » Devices » Overview after more than 5 minutes, follow the troubleshooting guide below.

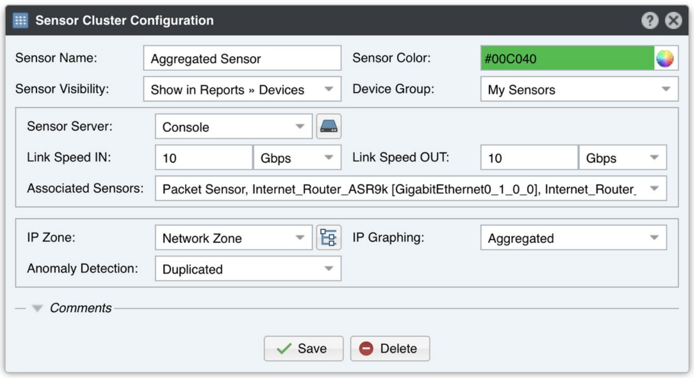
SNMP Sensor Troubleshooting

- ✔ Look for warnings or errors produced by the SNMP Sensor in the event log (details on page 69)
- ✔ Ensure that you have correctly configured the SNMP Sensor. Each configuration field is described in depth in this chapter
- ✔ Event log error "*License key not compatible with the existing server*" can be fixed by sending the string from Configuration » Servers » [SNMP Sensor server] » Hardware Key to sales@andrisoft.com
- ✔ Verify if the Console can reach the device by clicking the [**SNMP Tester & SNMP OIDs**] button from the SNMP Sensor Configuration window, then press [**Query Device**]
- ✔ Permit the server to contact the SNMP device, by configuring its ACL
- ✔ If Sensor graphs are spiky, increase the Polling Interval value.
- ✔ Make sure you are running the latest version of the software by checking Help » Software Updates

Configuration » Components » Sensor Cluster

Sensor Cluster aggregates traffic data provided by Packet Sensors and Flow Sensors into a single anomaly detection domain and/or IP graphing domain.

To add a Sensor Cluster, click the [+] button found on the title bar of the Configuration » Components panel. To configure an existing Sensor Cluster, go to Configuration » Components, and click its name.


Sensor Cluster Configuration

Sensor Name:	Aggregated Sensor	Sensor Color:	#00C040
Sensor Visibility:	Show in Reports » Devices	Device Group:	My Sensors
Sensor Server:	Console		
Link Speed IN:	10 Gbps	Link Speed OUT:	10 Gbps
Associated Sensors:	Packet Sensor, Internet_Router_ASR9k [GigabitEthernet0_1_0_0], Internet_Router_		
IP Zone:	Network Zone	IP Graphing:	Aggregated
Anomaly Detection:	Duplicated		

- **Sensor Name** – A short name to help you identify the Sensor Cluster
- **Server Color** – Color used in graphs for the Sensor Cluster. The default color is a random one, which can be changed by clicking the drop-down menu
- **Reports Visibility** – Toggles the listing inside Reports » Devices
- **Device Group** – Optional description used to group up components (e.g. by location or role). It can be used to restrict the access of Guest accounts
- **Sensor Server** – Which server runs the Sensor Cluster. It is recommended to run Sensor Clusters on the Console server. The configuration of servers is described on page 39
- **Link Speed IN / OUT** – Summed-up speeds (bandwidth, capacity) of the aggregated interfaces. These values can be used for percentage-based reports and percentage-based bits/s thresholds
- **Associated Sensors** – Select which Sensor interfaces are aggregated by the Sensor Cluster
- **IP Zone** – Sensor Cluster extracts from the selected IP Zone per-subnet settings about thresholds and/or IP graphing. For more information about IP Zones consult the “IP Zone” chapter on page 35
- **IP Graphing** – Select “Aggregated” to enable IP graphing by the Sensor Cluster for the summed up traffic data, and disable IP graphing by the associated Sensors. Select “Not Aggregated” to enable IP graphing by each associated Sensor and to disable IP graphing by the Sensor Cluster
- **Anomaly Detection** – Select “Aggregated” to enable anomaly detection by the Sensor Cluster for the summed up traffic data, and disable anomaly detection by the associated Sensors. Select “Not Aggregated” to enable anomaly detection by each associated Sensor and to disable anomaly detection by the Sensor Cluster. Enable aggregation only when the associated Sensors use Wanguard licenses, not Wansight. Select “Duplicated” to enable anomaly detection in the summed up traffic data by the Sensor Cluster, and also to enable anomaly detection by associated Sensors

- **Comments** – Comments about the Sensor Cluster can be saved here. These observations are not visible elsewhere

To start the Sensor Cluster, click the small button displayed next to its name in Configuration » Components.

Ensure that the Sensor Cluster starts correctly by watching the event log (see details on page 69) and by watching Reports » Devices » Overview.

Configuration » Components » BGP Connector

Wanguard Sensor and Wanguard Filter can send and withdraw BGP announcements (advertisements / routing updates) automatically, via Response actions (detailed on page 32), in the following cases:

- To protect your network by announcing DDoS'ed destinations to the upstream provider(s) with a special BGP community. Your side will no longer route the attacked addresses making them effectively null-routed by your BGP peers. This network protection technique is called blackhole routing, null-routing or RTBH (Remote Triggered Black Hole)
- To re-route attacked destinations through servers running Wanguard Filter, block attackers' packets and re-inject cleaned traffic back into the network. This network protection technique is called traffic scrubbing, clean pipe, side filtering or sinkhole routing
- To leverage BGP Flowspec for RTBH and/or traffic diversion
- To announce the attacking IP in BGP when S/RTBH is available

Console users can manage BGP announcements manually in Reports » Tools » Routing » [Create Black Hole] or [Divert Traffic]. All BGP routing updates are logged in Reports » Tools » Routing » BGP Announcement Archive.

If you do not need any of those features, you can safely skip this chapter.

You need to install and configure Quagga BGPd or ExaBGP (if your network supports Flowspec) before adding a BGP Connector. FRR is a fork of Quagga, so you can use it as a newer alternative. Most BGP-related configuration steps are listed in Appendix 3 – page 111 and in Appendix 4 – page 114.

A **BGP Connector** is a frontend to an existing Quagga BGPd or ExaBGP configuration. It is used solely to announce IPs, subnets or Flowspec rules to a previously configured backend, using the parameters from their configuration (route map, community, etc.).

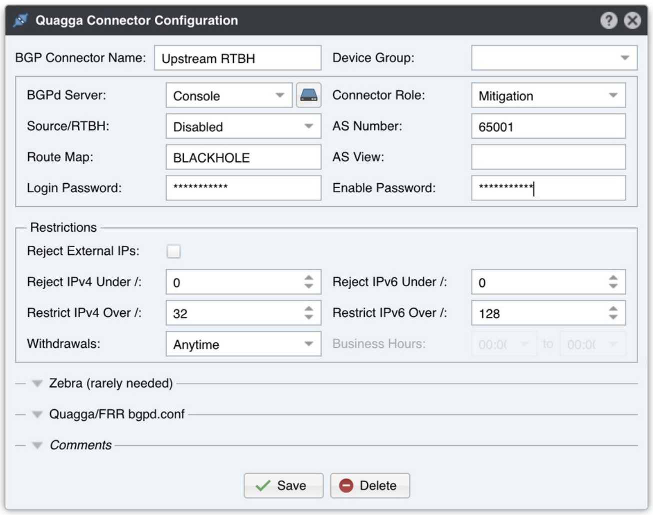
Wanguard supports two different backends for dealing with BGP announcements:

- **Quagga** and **FRR** provide a mature and widely used BGP daemon that closely resembles existing closed-source platforms like Cisco IOS. This is the recommended backend if support for BGP Flowspec is not needed
- **ExaBGP 4.0** is a Python-based tool, typically used outside the data plane to do path manipulation on a BGP network that may be composed of closed-source components. ExaBGP already supports newer technologies such as Flowspec

To add a BGP Connector, click the [+] button from the title bar of the Configuration » Components panel. To modify an existing BGP Connector, go to Configuration » Components and click its name.

BGP Connector for Quagga

Before adding a Quagga Connector, follow the steps from page 116.



BGP Connector Name:	Upstream RTBH	Device Group:	
BGPd Server:	Console	Connector Role:	Mitigation
Source/RTBH:	Disabled	AS Number:	65001
Route Map:	BLACKHOLE	AS View:	
Login Password:	***********	Enable Password:	***********

Restrictions

Reject External IPs:	☐		
Reject IPv4 Under /:	0	Reject IPv6 Under /:	0
Restrict IPv4 Over /:	32	Restrict IPv6 Over /:	128
Withdrawals:	Anytime	Business Hours:	00:0(to 00:0(

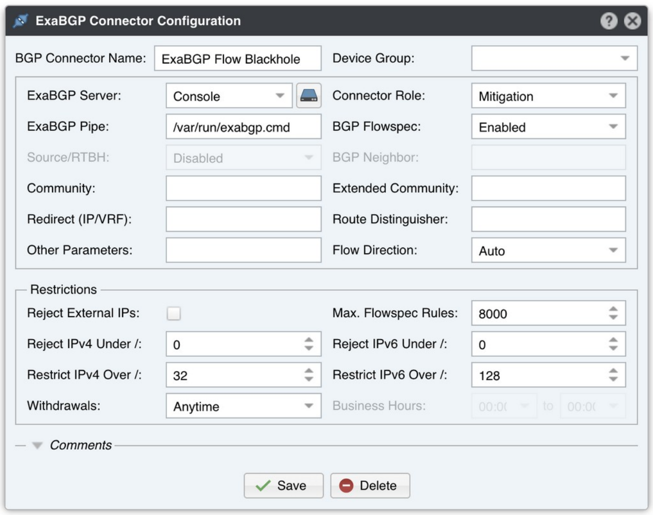
- **BGP Connector Name** – A short name or description of the BGP Connector
- **Device Group** – Optional description used to group up components (e.g. by location or role). It can be used to restrict the access of Guest accounts
- **BGPd Server** – Which server runs the Quagga BGPd daemon. Install the WANbgp and WANsupervisor packages on the selected server. The configuration of servers is described on page 39
- **Connector Role** – Set the correct role, "Diversion" or "Mitigation". If you have a single bgpd.conf for both roles, define two distinct BGP Connectors, one for the diversion route-map and community and one for the mitigation route-map and community
- **Source/RTBH** – Enable if the BGP Connector must be used for S/RTBH. If this is the case, add an S/RTBH action to the Response executed by Filter
- **AS Number** – The same AS number with the one from the BGPd configuration
- **Route Map** – A route-map that will be appended to each announcement. This option is not mandatory but widely used to add communities to the routing update
- **AS View** – If multiple AS views are defined in the BGPd configuration, you must enter the AS view you want to use for this configuration. This option is not mandatory and rarely used
- **Login Password** – Password needed to connect to the Quagga/FRR BGPd daemon
- **Enable Password** – Configuration mode password of the Quagga/FRR BGPd daemon
- **Reject External IPs** – When this option is selected, only the announcements for IPs/subnets defined inside an IP Zone (excluding 0.0.0.0/0) are sent
- **Reject IPv4 under /** – Restricts sending prefixes that have the IPv4 CIDR mask less than the configured value. For example, a value of 32 rejects all prefixes that are not hosts and prevents manual or automatic announcements of subnets. To disable this feature enter the value 0
- **Reject IPv6 under /** – Restricts sending prefixes that have the IPv6 CIDR mask less than the configured value. For example, a value of 128 rejects all prefixes that are not hosts and prevents manual or automatic

announcements of subnets. To disable this feature enter the value 0

- **Restrict IPv4 over /** – Set to the maximum IPv4 CIDR mask accepted by your cloud-based DDoS mitigation providers. For example, if your BGP peers accept only /24 prefixes, and you want to announce a whole C class for a single attacked IP, set to 24. To disable this feature enter the value 32
- **Restrict IPv6 over /** – Set to the maximum IPv6 CIDR mask accepted by your cloud-based DDoS mitigation providers. To disable this feature enter the value 128
- **Quagga Zebra Local Black Hole** – Check if you need the local black hole feature provided by the Zebra daemon. This rarely-used feature may be useful only for in-line servers
- **Quagga Zebra Login & Enable Passwords** – Passwords needed to connect to the zebra daemon
- **Quagga/FRR bgpd.conf** – The content of the bgpd.conf file downloaded by the WANsupervisor service. The file uses a format very similar to Cisco IOS configuration format. Quagga's and FRR's documentation covers all configuration options
- **Comments** – Comments about the BGP Connector can be saved here. These observations are not visible elsewhere

BGP Connector for ExaBGP

Before adding a ExaBGP Connector, follow the steps from page 118.


ExaBGP Connector Configuration

BGP Connector Name:	ExaBGP Flow Blackhole	Device Group:	
ExaBGP Server:	Console	Connector Role:	Mitigation
ExaBGP Pipe:	/var/run/exabgp.cmd	BGP Flowspec:	Enabled
Source/RTBH:	Disabled	BGP Neighbor:	
Community:		Extended Community:	
Redirect (IP/VRF):		Route Distinguisher:	
Other Parameters:		Flow Direction:	Auto

Restrictions

Reject External IPs:	☐	Max. Flowspec Rules:	8000
Reject IPv4 Under /:	0	Reject IPv6 Under /:	0
Restrict IPv4 Over /:	32	Restrict IPv6 Over /:	128
Withdrawals:	Anytime	Business Hours:	00:00 to 00:00

- **BGP Connector Name** – A short name or description for the BGP Connector
- **Device Group** – Optional description to group up components (e.g. by location or role). It can be used to restrict the access of Guest accounts
- **ExaBGP Server** – Which server runs ExaBGP. Install the WANbgp and WANsupervisor packages on the selected server. The configuration of servers is described on page 39
- **Connector Role** – Set the correct role, "Diversion" or "Mitigation"
- **ExaBGP Pipe** – Mandatory path to the *socat* pipe file used to control ExaBGP. Details on page 118
- **BGP Flowspec** – Enable if your network supports BGP Flowspec (RFC 5575)

- **Source/RTBH** – Enable if the BGP Connector must be used for S/RTBH. If this is the case, add an S/RTBH action to the Response executed by Filter
- **BGP Neighbor** – Optional parameter used to distinguish between BGP neighbors
- **Community** – BGP community or list of BGP communities to be appended to each announcement. Not mandatory
- **Extended Community** – BGP extended community or list of BGP extended communities to be appended to each announcement. Not mandatory
- **Redirect (IP/VRF)** – Optional parameter for diversion. Can be an IP, VRF or "self"
- **Route Distinguisher** – An optional rd value to be passed with each announcement
- **Other Parameters** – Other parameters that will be passed with each announcement, such as local-preference or as-path, in ExaBGP.conf format, separated by semicolon
- **Flow Direction** – Switches the source IP with the destination IP in each announcement. Set to "Inverted" only when doing symmetric routing
- **Reject External IPs** – When this option is selected, only the announcements for IPs/subnets defined inside an IP Zone (excluding 0.0.0.0/0) are sent
- **Max. Flowspec Rules** – The number of Flowspec rules accepted by each router is limited, so you may have to enter the limit here to prevent overflowing the number of rules
- **Reject IPv4 under /** – Restricts sending prefixes that have the IPv4 CIDR mask less than the configured value. For example, a value of 32 rejects all prefixes that are not hosts and prevents manual or automatic announcements of subnets. To disable this feature enter the value 0
- **Reject IPv6 under /** – Restricts sending prefixes that have the IPv6 CIDR mask less than the configured value. For example, a value of 128 rejects all prefixes that are not hosts and prevents manual or automatic announcements of subnets. To disable this feature enter the value 0
- **Restrict IPv4 over /** – Set to the maximum IPv4 CIDR mask accepted by your cloud-based DDoS mitigation providers. For example, if your BGP peers accept only /24 prefixes, and you want to announce a whole C class for a single attacked IP, set to 24. To disable this feature enter the value 32
- **Restrict IPv6 over /** – Set to the maximum IPv6 CIDR mask accepted by your cloud-based DDoS mitigation providers. To disable this feature enter the value 128
- **Comments** – Comments about the BGP Connector can be saved here. These observations are not visible elsewhere

Start ExaBGP version 4.x on the host, then enable the BGP Connector by clicking the small button displayed next to its name in Configuration » Components.

You can manually send a test BGP announcement with an unused/test IP address in Reports » Tools » Routing » [Black Hole] or [Divert Traffic]. If you encounter errors, follow the troubleshooting guide below:

BGP Connector Troubleshooting

- ✔ Ensure that you have correctly configured the BGP Connector. Each configuration field is described in depth in this chapter
- ✔ Look for warnings or errors produced by the BGP Connector in Reports » Tools » Routing » BGP Connector Events (details on page 69)
- ✔ Telnet connection errors on port tcp/2605 in the event log indicate that the Quagga BGPd daemon is not accessible via telnet. By default, Debian systems bound bgpd to 127.0.0.1, which is why the string "-A 127.0.0.1" must be deleted from /etc/quagga/debian.conf
- ✔ Telnet connection errors on port tcp/2601 indicate that the Quagga BGP Connector was configured with the Quagga Zebra Local Back Hole feature, but the zebra daemon is not configured or accessible from the Console server
- ✔ Telnet errors about pattern time-outs indicate mismatches between a parameter defined in the BGP Connector (password, AS number, route-map, AS view) and the similar parameter from bgpd.conf
- ✔ You can clear BGP prefix errors from Reports » Tools » Routing » Active BGP Announcements » Batch Actions » [Clear], or by clicking the stop button for each announcement
- ✔ Errors about "orphaned" announcements indicate that the BGP announcement is still active after the anomaly has ended. The BGP announcements are withdrawn by the Sensor that detected the anomaly, immediately after the anomaly ends.

  Orphaned announcements can have multiple reasons:

  - The anomaly was ended forcefully by clicking the [Expire] button in Reports » Tools » Anomalies
  - The Sensor that detected the anomaly was deleted or is not running anymore
  - The WANsupervisor was not running at the time of the withdrawal
  - Networking errors between the Console server and the server running bgpd. If this is the case, you should see the exact telnet error in the event log's details.
- ✔ Make sure you are running the latest version of the software by checking Help » Software Updates

Configuration » Components » Packet Filter

The functionality of Wanguard Filter is briefly described on page 10 in the chapter “Choosing a Method of DDoS Mitigation”.

Packet Filter can be deployed in one of the following topologies:

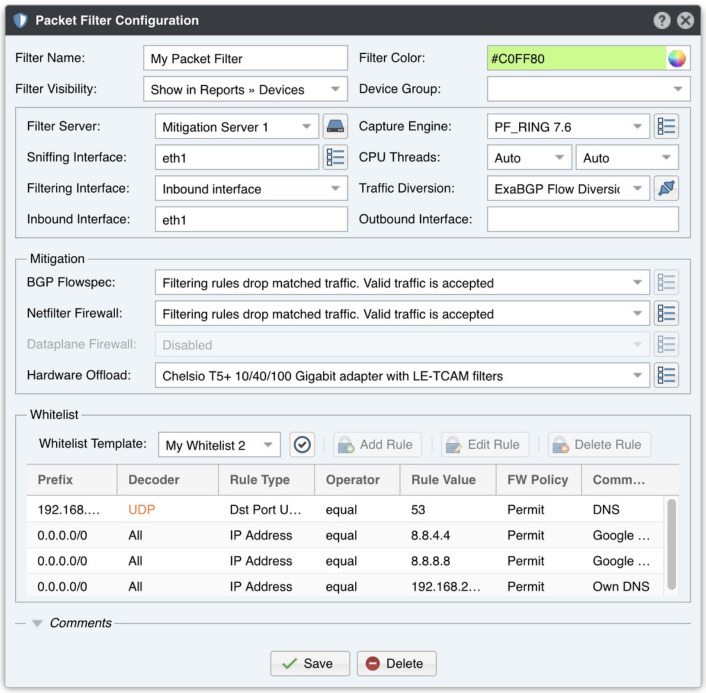
- *Inline filtering* – Packet Filter runs on a server that resides in the main data path, configured as a network bridge or as an OSI Layer 3 router. To enable routing on the filtering server follow the steps required by your Linux distribution. At least the following commands need to be executed:

  ```
  sysctl -w net.ipv4.ip_forward=1;
  sysctl -w net.ipv4.conf.all.forwarding=1;
  sysctl -w net.ipv4.conf.default.rp_filter=0;
  sysctl -w net.ipv4.conf.all.rp_filter=0
  ```

  To run Packet Filter in this mode, set the interface connected to the peering/border router as Inbound Interface. To inject the packets back into the network, set a core router as the default gateway, reachable through the Outbound Interface, either directly (recommended) or through a GRE or IP-in-IP tunnel.

  To configure the filtering server as a network bridge, follow the steps required by your Linux distribution. To run Packet Filter in this mode, set the Inbound Interface to the bridged interface (usually br0).
- *Inline monitoring* – Packet Filter runs on a server that resides in the main data path, configured as an OSI Layer 3 router or network bridge. Direct filtering is disabled, but the filtering rules will improve the visibility of attacks and can be applied to other in-line appliances, firewalls, or sent via FlowSpec. To run Packet Filter in this mode, set the parameters like in the Inline filtering mode.
- *Out-of-line filtering* – To run Packet Filter in this mode, set the Traffic Diversion parameter to a BGP Connector configured for rerouting traffic. Other parameters must be set as in the Inline filtering mode.
- *Out-of-line monitoring* – Packet Filter runs on a server that receives a copy of packets from a network TAP or mirroring port. Direct filtering is disabled, but the filtering rules will improve the visibility of attacks and can be applied to other in-line appliances, firewalls, or sent via FlowSpec. To run Packet Filter in this mode, set the Sniffing Interface to be the same as the Sniffing Interface configured in Packet Sensor.

To add a Packet Filter, click the [+] button found in the title bar of the Configuration » Components panel. To configure an existing Packet Filter, go to Configuration » Components and click its name.


Packet Filter Configuration

Filter Name: My Packet Filter
Filter Color: #C0FF80
Filter Visibility: Show in Reports » Devices
Device Group:
Filter Server: Mitigation Server 1
Capture Engine: PF_RING 7.6
Sniffing Interface: eth1
CPU Threads: Auto Auto
Filtering Interface: Inbound interface
Traffic Diversion: ExaBGP Flow Diversi
Inbound Interface: eth1
Outbound Interface:

Mitigation
BGP Flowspec: Filtering rules drop matched traffic. Valid traffic is accepted
Netfilter Firewall: Filtering rules drop matched traffic. Valid traffic is accepted
Dataplane Firewall: Disabled
Hardware Offload: Chelsio T5+ 10/40/100 Gigabit adapter with LE-TCAM filters

Whitelist
Whitelist Template: My Whitelist 2

Prefix	Decoder	Rule Type	Operator	Rule Value	FW Policy	Comm...
192.168....	UDP	Dst Port U...	equal	53	Permit	DNS
0.0.0.0/0	All	IP Address	equal	8.8.4.4	Permit	Google ...
0.0.0.0/0	All	IP Address	equal	8.8.8.8	Permit	Google ...
0.0.0.0/0	All	IP Address	equal	192.168.2...	Permit	Own DNS

- **Filter Name** – A short name that helps you identify the Packet Filter
- **Filter Color** – Color used in graphs for the Packet Filter. The default color is a random one, which can be changed by clicking the drop-down menu
- **Filter Visibility** – Select if the Packet Filter should be listed in Reports » Devices
- **Device Group** – Optional description used within Console to group up components (e.g. by location or role). It can be used to restrict the access of Guest accounts
- **Filter Server** – Which Server runs the Packet Filter. The configuration of servers is described on page 39
- **Capture Engine** – Select the preferred packet capturing engine. LibPcap requires no additional setup but it is often too slow for multi-gigabit sniffing and it does not run on multiple threads. PF_RING is much faster but requires the installation of an additional kernel module. DPDK provides the fastest packet capturing engine but it is much more complicated to setup and the allocated CPUs will always be used at 100%.
    - *Embedded LibPcap* – Select to use the built-in LibPcap 1.8.1 library
    - *System LibPcap* – Select to use the LibPcap library installed by the Linux distribution
    - *PF_RING* – Select to use the PF_RING framework to speed up packet processing. Click the options button for PF_RING-specific settings
    - *DPDK* – Select to use the DPDK framework, then click the options button to configure DPDK-specific parameters as described in Appendix 6 on page 134
    - *DPDK [Packet Sensor]* – Select to use a DPDK-enabled Packet Sensor as a packet capturing engine. DPDK offers exclusive access to the hardware to a single process, so this option embeds the Packet Filter's logic into a Packet Sensor in order to have both Wanguard components listening to the same interface
- **Capture Engine Options** – This button shows specific options for the selected Capture Engine.

The **Packet Sampling (1/N)** field is enabled for all capturing engines, and it must be equal to the number of filtering servers activated for the same anomaly when the Packet Filter is used in a clustered architecture where each filtering server receives traffic from a round-robin packet scheduler. The correct value in most cases is 1

- **Sniffing Interface** – Network interface(s) listened by the Packet Filter. Listening to the Inbound Interface increases CPU usage because even the traffic that doesn't get forwarded must to be inspected. Listening to the Outbound Interface decreases CPU usage because only the forwarded traffic reaches that interface. Packet Filter can still obtain traffic statistics about the dropped traffic by inspecting the firewall's counters
- **CPU Threads** – Depending on the chosen Capture Engine, Packet Filter can run multi-threaded on a given set of CPU cores. Each thread increases the RAM usage. On most systems, activating more than 6 CPU threads hurts performance
- **Filtering Interface** – Select where to apply the filtering rules:
    - *None* – Packet Filter does not apply the filtering rules directly
    - *Inbound* – Packet Filter applies the filtering rules on the inbound Interface
    - *Outbound* – Packet Filter applies the filtering rules on the outbound interface
- **Traffic Diversion** – Provides a selection of BGP Connectors that can be used for traffic diversion. If the server is deployed in-line, or if you do not plan to use traffic diversion, leave the field set to "None".

  When a BGP Connector is selected, the Packet Filter sends routing updates that set the server as next-hop for the attacked IP addresses. When the attack ends, the announcement is automatically withdrawn which causes the traffic towards the attacked IP to be routed normally.

  For more information about BGP Connectors, consult the "BGP Connector" chapter on page 55
- **Inbound Interface** – Enter the interface that receives incoming traffic. For a bridged interface, prepend the string *physdev:* in front of the interface name
- **Outbound Interface** – The cleaned traffic is sent to the downstream router/switch via the outbound interface, which should hold the route to the default gateway. For GRE / IP over IP tunneling, configure virtual network interfaces with the *ip* command, part of the *iproute2* package. For a bridged interface, prepend the string *physdev:* in front of the interface name
- **BGP Flowspec** – Select which policy to apply when the Response is configured to send BGP FlowSpec announcements for filtering rules
- **Netfilter Firewall** – Select the Netfilter policy that will be applied when the Packet Filter generates a filtering rule. Packet Filter can do software-based packet filtering and packet rate limiting using the Netfilter framework provided by the Linux kernel. The software-based packet filter is very flexible, and since Packet Filter does not use the connection tracking mechanism specific to stateful firewalls, it is very fast as well.
    - *Disabled* – Packet Filter detects and reports filtering rules, but the Linux firewall API is not used
    - *Filtering rules drop matched traffic. Valid traffic is accepted* – Packet Filter detects, reports and applies filtering rules using the Netfilter firewall. If the filtering rule is not whitelisted, the traffic matched by it is blocked. The remaining traffic passes
    - *Filtering rules drop matched traffic. Valid traffic is rate-limited* – Packet Filter detects, reports and applies filtering rules, and rate-limits the remaining traffic. If the filtering rule is not whitelisted, the traffic matched by it is blocked. The traffic that exceeds the packets/second threshold value is not passed. Rate-limiting is supported by Netfilter only for packets/s thresholds, not for bits/s thresholds Also, some kernel versions will fail to rate-limit traffic above 10000 pkts/s and will block all traffic

instead!

- *Filtering rules rate-limit matched traffic. Valid traffic is accepted* – Packet Filter detects and reports filtering rules and rate-limits matched traffic to the threshold value. Rate-limiting is supported by Netfilter only for packets/s thresholds, not for bits/s thresholds Also, some kernel versions will fail to rate-limit traffic above 10000 pkts/s and will block all traffic instead!
- *Apply the default Netfilter chain policy* – Packet Filter detects and reports filtering rules, and applies the default Netfilter chain policy. The Netfilter framework is still being used, but all rules have the "RETURN" target. This option is usually used for testing and debugging purposes

Click the options button on the right to be able to configure the following additional parameters:

- **Netfilter Chain** – set to *FORWARD* if the server forwards traffic or *INPUT* if it does not
- **Netfilter Table** – the *raw* option requires both Inbound and Outbound interfaces to be set, and doesn't work for all virtual interfaces. It provides a better packet filtering performance compared to the *filter* option

- **Dataplane Firewall** – This option selects the policy of the Dataplane Firewall, which is a built-in software-based firewall that uses DPDK as a Capture Engine. It is better performing than Netfilter but less flexible.
- **Hardware Offload** – If you have a NIC that provides hardware filters, select the appropriate option. Since hardware filters do not consume CPU, use this option to complement the Netfilter Firewall and Dataplane Firewall.
  - *Disabled* – Hardware filters are not applied
  - *DPDK Flow API* – Packet Filter uses the Flow API supported by several DPDK-supported NIC chipsets (Chelsio, Intel, etc.) to offload the filtering of packets to the hardware
  - *Intel x520+ 1/10/40 Gigabit adapter configured to block IPv4 sources* – Packet Filter programs the Intel chipset to drop IPv4 addresses from filtering rules that contain source IPs. Up to 4086 hardware filters are possible
  - *Intel x520+ 1/10/40 Gigabit adapter configured to block IPv4 destinations* – Packet Filter programs the Intel chipset to drop IPv4 addresses from filtering rules that contain destination IPs. Up to 4086 hardware filters are possible
  - *Chelsio T5+ 10/40/100 Gigabit adapter with LE-TCAM filters* – Packet Filter uses the Chelsio API to apply up to 487 filtering rules that contain any combination of source/destination IPv4/IPv6 addresses, source/destination UDP/TCP port, and IP protocol
- **Whitelist** – A Filter Whitelist is a collection of user-created rules that prevent the filtering of critical traffic. To add similar rules for multiple Filters, configure a new Whitelist Template in Configuration » Network & Policy.

  Packet Filter might block attack patterns that you don't want to be blocked. Destination ports and destination IP addresses are blocked only in worst-case scenarios when no other attack pattern is found. In some cases, it is better to let potential malicious traffic enter the network than to filter critical traffic. For example, if your DNS server is attacked by spoofed addresses on port 53 UDP, Packet Filter might block port 53 UDP traffic towards your DNS server, making it partially unreachable from the Internet. In this case, configure a whitelist rule (Rule Type: *Dst Port UDP*, Operator: *equal*, Rule Value: *53*) and review the settings from Configuration » General Settings » Anomaly Mitigation.

  To add a new rule to the whitelist, enter the following information:

  - **Prefix** – Enter a subnet that must include the anomaly IP address, for the whitelist rule to be valid only for that particular subnet. Enter 0.0.0.0/0 for a generic whitelist rule

  - **Decoder** – Select the decoder of the anomaly, or select *All* for a generic whitelist rule
  - **Rule Type** – Possible values: *Source IP, Src Port TCP, Dst Port TCP, Src Port UDP, Dst Port UDP, Packet Length, IP TimeToLive, IP Protocol*
  - **Operator** – Operators for strings and numbers: *equal, non-equal.* Operators for numbers: *less than, greater than.* The operator *equal* can match IP Addresses in CIDR notation and port ranges written as <port_min>:<port_max>
  - **Rule Value** – A user-defined value that should match
  - **FW Policy** – When **FW Policy** is *Permit* and **Operator** is *equal,* the Packet Filter explicitly allows the matched traffic to pass through the Netfilter Firewall. Otherwise, a more generic filtering rule might take precedence over the whitelisted filtering rule
  - **Description** – An optional description for the whitelist rule

  When a filtering rule cannot be applied because it conflicts with a whitelist rule, a small white flag icon appears next to it in Console reports.

- **Comments** – Comments about the Packet Filter can be saved here. These observations are not visible elsewhere

Enable the Packet Filter by clicking the small play/stop button displayed next to its name in Configuration » Components.

An instance of the Packet Filter will be launched when a traffic anomaly triggers the Response action “Detect filtering rules and mitigate the attack with Wanguard Filter”.

Packet Filter Troubleshooting

- ✔ To view the counters for each Netfilter or Chelsio filtering rule go to Reports » Tools » Firewall
- ✔ To see the filtering rules applied by the Netfilter firewall via the CLI:

  ```
  iptables -L -n -v && iptables -L -n -v  -t raw
  ```

  To delete all chains:

  ```
  for chain in `iptables -L -t raw | grep wanguard | awk '{ print $2 }'`; do
  iptables -X $chain; done
  ```

- ✔ To view the filtering rules applied on the Intel 80599 chipset:

  ```
  ethtool --show-ntuple <filtering_interface>
  ```

  or, for kernels >3.1:

  ```
  ethtool --show-nfc <filtering_interface>
  ```

- ✔ To ensure that filtering rules can be applied on the Intel 80599 chipset, load the ixgbe driver with the parameter `FdirPballoc=3`. To prevent getting “*Location out of range*” errors from the ixgbe driver, load it with the right parameters in order to activate the maximum number of 8k filtering rules
- ✔ To view filtering rules applied on the Chelsio T4+ chipset:

  ```
  cxgbtool <filtering_interface> filter show
  ```

✔ If the CPU usage of the Packet Filter instance is too high, install PF_RING (no ZC/DNA/LibZero needed), or use a network adapter that allows distributing Packet Filters over multiple CPU cores

✔ For PF_RING installation issues, contact ntop.org. To increase the maximum number of PF_RING programs from 64 to 256, increase the MAX_NUM_RING_SOCKETS defined in kernel/linux/pf_ring.h and recompile the pf_ring kernel module

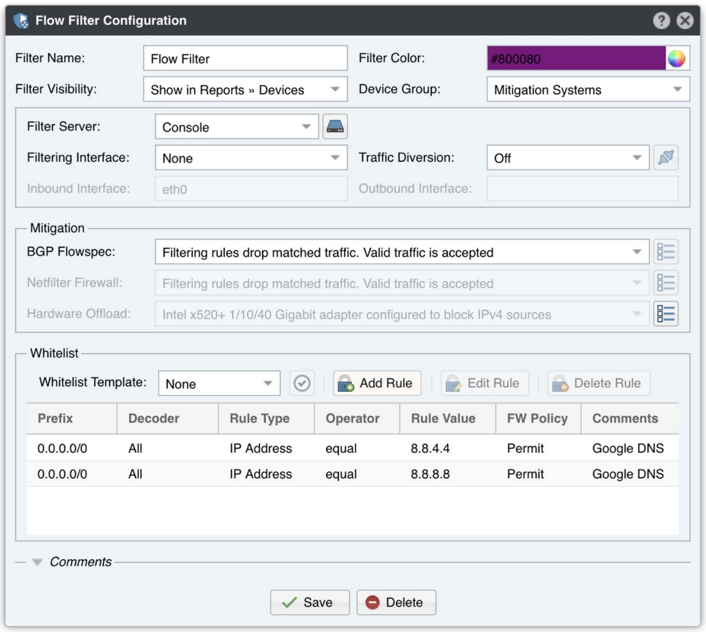
✔ Event log error "*License key not compatible with the existing server*" can be fixed by sending the string from Configuration » Servers » [Packet Filter's server] » Hardware Key to sales@andrisoft.com

✔ Make sure you are running the latest version of the software by checking Help » Software Updates

Configuration » Components » Flow Filter

The functionality of Wanguard Filter is briefly described in a chapter from page 10 named “Choosing a Method of DDoS Mitigation”, and also on page 60.

To add a Flow Filter, click the [+] button found in the title bar of the Configuration » Components panel. To configure an existing Flow Filter, go to Configuration » Components and click its name.



Flow Filter Configuration

Filter Name: Flow Filter
Filter Color: #800080
Filter Visibility: Show in Reports » Devices
Device Group: Mitigation Systems
Filter Server: Console
Filtering Interface: None
Traffic Diversion: Off
Inbound Interface: eth0
Outbound Interface:

Mitigation
BGP Flowspec: Filtering rules drop matched traffic. Valid traffic is accepted
Netfilter Firewall: Filtering rules drop matched traffic. Valid traffic is accepted
Hardware Offload: Intel x520+ 1/10/40 Gigabit adapter configured to block IPv4 sources

Whitelist
Whitelist Template: None

Prefix	Decoder	Rule Type	Operator	Rule Value	FW Policy	Comments
0.0.0.0/0	All	IP Address	equal	8.8.4.4	Permit	Google DNS
0.0.0.0/0	All	IP Address	equal	8.8.8.8	Permit	Google DNS

Every parameter is already documented in the previous chapter from page 60.

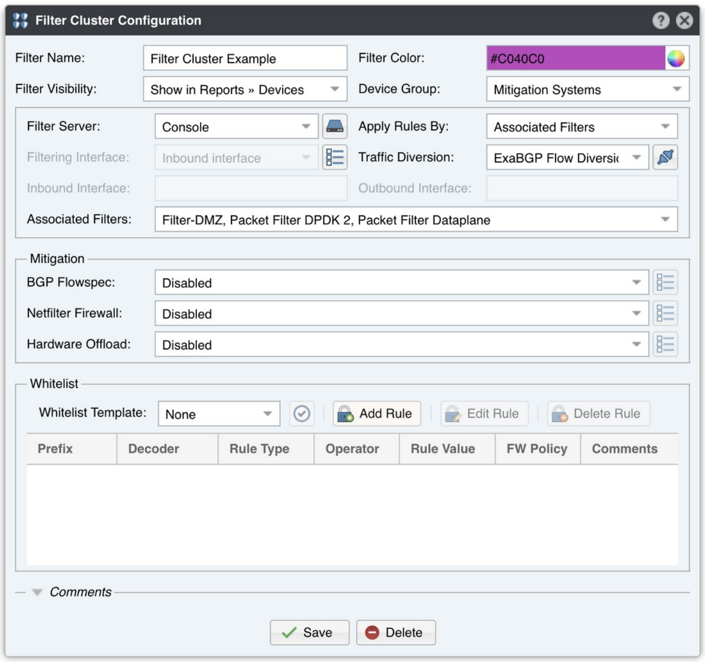
Enable the Flow Filter by clicking the small play/stop button displayed next to its name in Configuration » Components.

An instance of the Flow Filter is launched when a traffic anomaly triggers the Response action “Detect filtering rules and mitigate the attack with Wanguard Filter”.

Configuration » Components » Filter Cluster

The functionality of Wanguard Filter is briefly described in a chapter from page 10 named "Choosing a Method of DDoS Mitigation", and also on page 60.

To add a Filter Cluster, click the [+] button found in the title bar of the Configuration » Components panel. To configure an existing Filter Cluster, go to Configuration » Components and click its name.



Filter Name: Filter Cluster Example
Filter Color: #C040C0
Filter Visibility: Show in Reports » Devices
Device Group: Mitigation Systems
Filter Server: Console
Apply Rules By: Associated Filters
Filtering Interface: Inbound interface
Traffic Diversion: ExaBGP Flow Diversi
Inbound Interface:
Outbound Interface:
Associated Filters: Filter-DMZ, Packet Filter DPDK 2, Packet Filter Dataplane

Mitigation
BGP Flowspec: Disabled
Netfilter Firewall: Disabled
Hardware Offload: Disabled

Whitelist
Whitelist Template: None

Prefix	Decoder	Rule Type	Operator	Rule Value	FW Policy	Comments

Every parameter is already documented in the previous chapter from page 60, apart from:

- **Apply Rules By** – Select where to apply the filtering rules detected by the Filter Cluster:
  - *Associated Filters* – Filtering rules are applied on each server running an associated Filter
  - *Filter Cluster* – Filtering rules are applied only on the server running the Filter Cluster
- **Associated Filters** – Select the Filters that should be aggregated by the Filter Cluster. The associated Filters are launched by the Filter Cluster instance and need not be launched individually via a Response

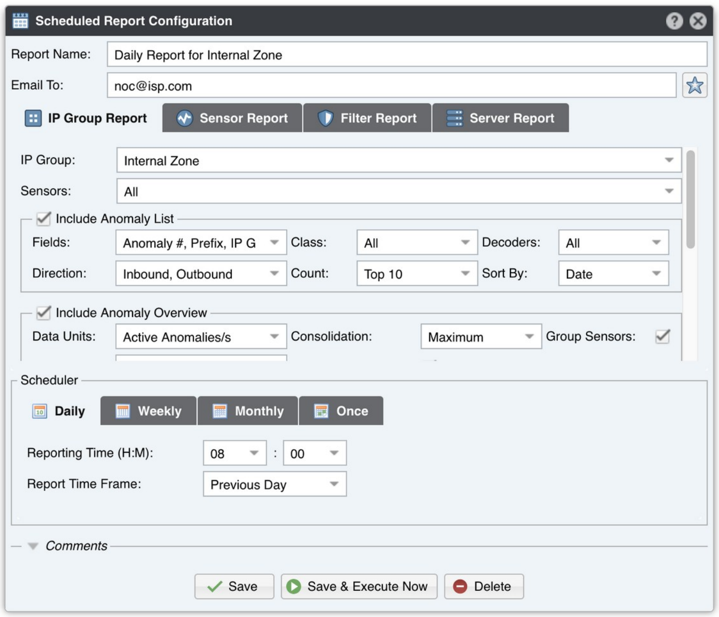
Enable the Filter Cluster by clicking the small play/stop button displayed next to its name in Configuration » Components.

An instance of the Filter Cluster is launched when a traffic anomaly triggers the Response action "Detect filtering rules and mitigate the attack with Wanguard Filter".

Configuration » Schedulers » Scheduled Reports

One of the greatest strengths of this software is the ease with which you can generate complex Reports. Most reports created by clicking items from the Reports Region can be printed, exported as PDFs or sent by email.

If you want to receive periodic reports by email without having to log in, go to Configuration » Schedulers and click the [+] button from the title bar of the panel.


Scheduled Report Configuration

Report Name: Daily Report for Internal Zone
Email To: noc@isp.com

IP Group Report | Sensor Report | Filter Report | Server Report

IP Group: Internal Zone
Sensors: All

✓ Include Anomaly List
Fields: Anomaly #, Prefix, IP G | Class: All | Decoders: All
Direction: Inbound, Outbound | Count: Top 10 | Sort By: Date

✓ Include Anomaly Overview
Data Units: Active Anomalies/s | Consolidation: Maximum | Group Sensors: ✓

Scheduler
Daily | Weekly | Monthly | Once
Reporting Time (H:M): 08 : 00
Report Time Frame: Previous Day

Comments

Save | Save & Execute Now | Delete

You can include more than one email address in the **Email To** field by separating addresses with a comma.

The emails are sent periodically according to the settings from the **Scheduler** tab. Only the active tab is taken into consideration.

To see how the email would look like without waiting for the preconfigured time, enter your email address, and then click the [**Save & Execute Now**] button. You should receive an email containing the report within a few seconds. If you do not, verify the settings from Configuration » General Settings » Outgoing Email.

All emails are formatted as HTML messages and include MIME attachments.

Configuration » Schedulers » Event Reporting

Events are short text messages that describe errors, warnings or the change of an operational status. They are generated by Wanguard components and logged by Console.

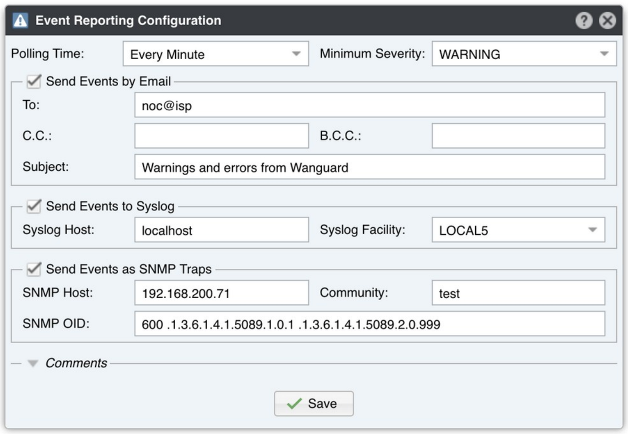
You can list events in Reports » Devices » [Component Name] » [Component Type] Event sub-tab. To search, sort or filter event messages, click the small down arrow that appears when hovering over the Event column header. To see additional details about an event click the [+] button from the first column.

To see a recent list of **Latest Events**, click the small bottom edge of the window to raise the South Region, or press Ctrl+E. On one side the Latest Events tab displays the latest 50 events, while on the other side it shows a list of components that can generate events and the number of events generated in the last 24 hours by each component. The number's color indicates the maximum severity of the events: red means that there are ERRORS, blue is for INFO events, etc.

The event's **severity** indicates its importance:

- **MELTDOWN** – Meltdown events are generated in severe situations, such as hardware failures
- **CRITICAL** – Critical events are generated when significant software errors occur, such as a memory exhaustion situation
- **ERROR** – Error events are usually caused by misconfigurations, communication errors between components, or even bugs. Sensors auto-recover from errors by restarting themselves
- **WARNING** – Warning events are generated when authentication errors occur, on I/O bottlenecks or when there are time synchronization issues
- **INFO** – Informational events are generated when configurations are changed or when users log in
- **DEBUG** – Debug events are generated only to help troubleshooting or the development process

As an administrator, you should keep events with high severities under surveillance! Configure Console to send important events periodically by email, Syslog or SNMP in Configuration » Schedulers » Event Reporting.



Polling Time: Every Minute
Minimum Severity: WARNING

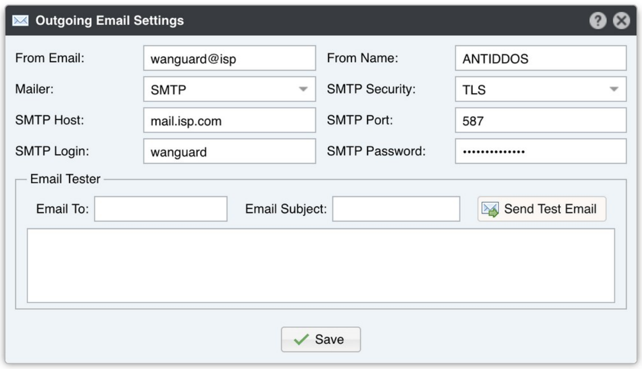
✓ Send Events by Email
To: noc@isp
C.C.:
B.C.C.:
Subject: Warnings and errors from Wanguard

✓ Send Events to Syslog
Syslog Host: localhost
Syslog Facility: LOCAL5

✓ Send Events as SNMP Traps
SNMP Host: 192.168.200.71
Community: test
SNMP OID: 600 .1.3.6.1.4.1.5089.1.0.1 .1.3.6.1.4.1.5089.2.0.999

Configuration » General Settings » Outgoing Email

Console sends notification emails using the settings from Configuration » General Settings » Outgoing Email:



From Email:	wanguard@isp	From Name:	ANTIDDOS
Mailer:	SMTP	SMTP Security:	TLS
SMTP Host:	mail.isp.com	SMTP Port:	587
SMTP Login:	wanguard	SMTP Password:	••••••••••••••

Email To: Email Subject:

- **From Email** – The address you would like to appear as the sender
- **From Name** – The name as you would like it to appear as the sender
- **Mailer** – Console supports several mailing systems:
    - *PHP Mail* – Use the PHP mail() function. To use it, you may have to configure a Mail Transfer Agent (Postfix, Qmail, Sendmail) on the Console server
    - *SMTP* – Use the integrated SMTP support to send emails directly, without using a local Mail Transfer Agent
    - *Sendmail* – Send emails using the sendmail command. To use it, you may have to configure a Mail Transfer Agent (Postfix, Qmail, Sendmail) on the Console server
- **SMTP Security** – Security options:
    - *None* – No encryption
    - *SSL* – Enable SSL encryption
    - *TLS* – Enable TLS encryption
- **SMTP Host** – Specify the SMTP server(s). You can include backup SMTP server(s) separated by the ";" character
- **SMTP Port** – TCP port to connect to, usually 25 (insecure) or 587 (secured by SSL/TLS)
- **SMTP Login/Password** – Credentials used for SNMP authentication. When the fields are empty, no authentication is performed
- **Email Tester** – Send a test email to verify the settings

If you can send emails with the Email Tester, but you are not receiving emails sent via Response actions, check if there are errors when executing the command "php /opt/andrisoft/webroot/rep_reports.php" from CLI.

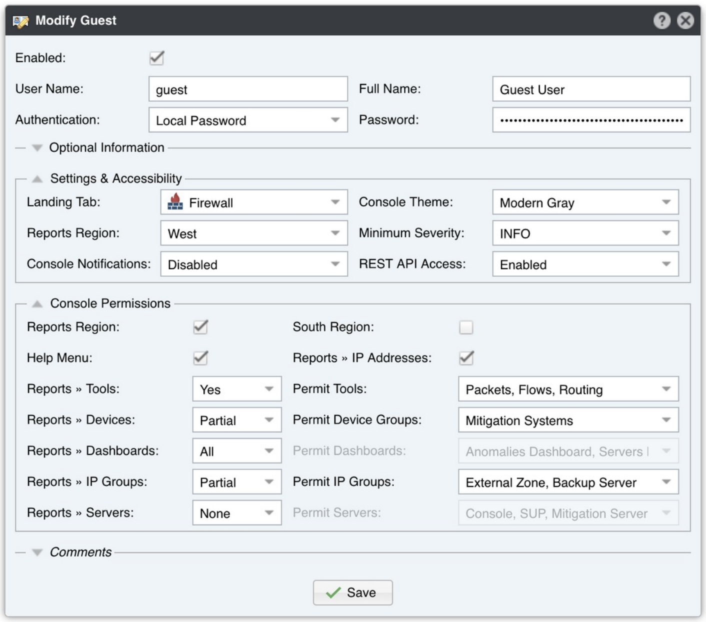
Configuration » General Settings » User Management

To add, modify or delete Console user accounts go to Configuration » General Settings » User Management.

Each Console user must be assigned to one role / access level:

- **Administrator** – Has full privileges and is allowed to manage other user accounts. Is the only role allowed to access Configuration » General Settings » License Manager
- **Operator** – Can change any configuration but is not authorized to modify other user accounts
- **Guest** – Has read-only access to Console, without access to any configuration. Can have a granular, permission-based access to specific reports, dashboards, Sensors, IP groups, tools, etc.

To add a Console account, press [**Add User**] and the select the desired role. You can modify an account by double-clicking it, or by selecting it and by pressing the [**Modify User**] button.



Enabled:	✓		
User Name:	guest	Full Name:	Guest User
Authentication:	Local Password	Password:	•••••••••••••••••••••••••••••••••••

Landing Tab:	Firewall	Console Theme:	Modern Gray
Reports Region:	West	Minimum Severity:	INFO
Console Notifications:	Disabled	REST API Access:	Enabled

Reports Region:	✓	South Region:	
Help Menu:	✓	Reports » IP Addresses:	✓
Reports » Tools:	Yes	Permit Tools:	Packets, Flows, Routing
Reports » Devices:	Partial	Permit Device Groups:	Mitigation Systems
Reports » Dashboards:	All	Permit Dashboards:	Anomalies Dashboard, Servers I
Reports » IP Groups:	Partial	Permit IP Groups:	External Zone, Backup Server
Reports » Servers:	None	Permit Servers:	Console, SUP, Mitigation Server

The **Enabled** checkbox enables or disables the selected account.

There are two **Authentication** options:

- *Local Password* – The user will be authenticated with the password entered in the **Password** field. All passwords are hashed and only the hash is stored in the database, so it's not possible to decrypt them
- *Remote Authentication* – The user will be authenticated by remote LDAP or RADIUS servers configured in Configuration » General Settings » User Authentication (details on page 73)

The **Full Name**, **Company**, **Position**, **Email, Phone** and **Comments** fields are optional. These details are not visible anywhere else.

Landing Tab shows the tab that opens immediately after logging in. The list is dynamic and expands as you add Sensors, dashboards, IP groups, etc. You should probably set the Landing Tab to a relevant dashboard or report.

Minimum Severity shows the minimum severity level of events displayed in Console.

Reports Region lets you switch the position of the Reports Region (described on page 20).

Configuration Region lets you switch the position of the Configuration Region (described on page 20).

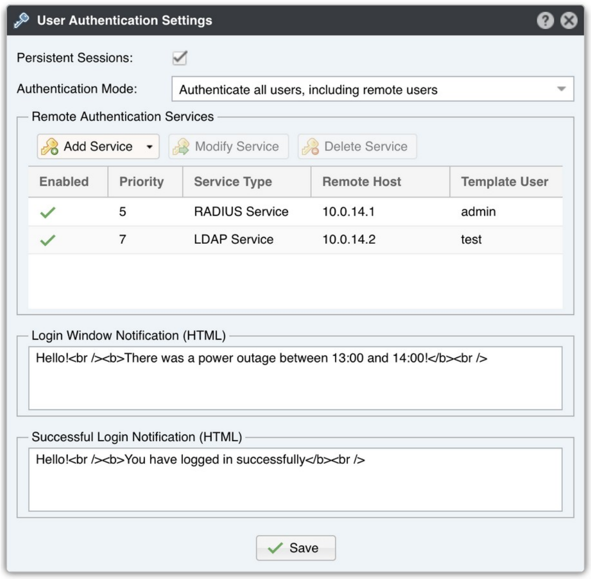
Console Theme allows you to change how Console looks after re-login.

Console Notifications manages the visual and audio notifications sent by Responses.

REST API Access controls whether the user has access to the REST API using his credentials. The REST API is documented on *http://<console_ip>/wanguard-api-ui* or *https://<console_ip>/wanguard-api-ui.*

Configuration » General Settings » User Authentication

To configure remote authentication mechanisms and login window settings click Configuration » General Settings » User Authentication.



Persistent Sessions: ✓

Authentication Mode: Authenticate all users, including remote users

Remote Authentication Services

Enabled	Priority	Service Type	Remote Host	Template User
✓	5	RADIUS Service	10.0.14.1	admin
✓	7	LDAP Service	10.0.14.2	test

Login Window Notification (HTML)

```
Hello!<br /><b>There was a power outage between 13:00 and 14:00!</b><br />
```

Successful Login Notification (HTML)

```
Hello!<br /><b>You have logged in successfully</b><br />
```

Persistent Sessions enables cookie-based authentication for Console users that select the *Remember* option in the login screen. Subsequent sessions skip the login screen for the next 30 days or until the user logs out.

Authentication Mode enables or disables the authentication of Console users that are not defined in Configuration » General Settings » User Management but are defined in LDAP or Radius.

Console permits the use of external Radius and LDAP servers for end user authentication.

LDAP server settings:

- **Priority** – You can set the order in which Console connects to multiple authentication services. The authentication process stops after the first successful authentication
- **Template User** – Remotely-authenticated users without a Console account have the privileges of the Template User
- **LDAP Host** – IP or hostname of the LDAP server. To connect to a LDAP server by SSL, set this parameter as *ldaps://<IP>/*
- **Login Attribute** – Enter the LDAP attribute that contains the username. For Active Directory it usually is *mailNickname* or *sAMAccountName*, for OpenLDAP or IBM Directory Server it could be *uid*
- **LDAP Base DN** – Specify the location in the LDAP hierarchy where Console should begin searching for usernames for authorization requests. The base DN may be something equivalent to the organization, group, or domain name (AD) of the external directory: *dc=domain,dc=com*

- **Bind User DN/Password** – Distinguished name and password for a LDAP user permitted to search within the defined Base DN
- **Search Filter** – Can contain rules that restrict which users are authenticated using the current configuration. For example, the string "|(department=*NOC*)(department=ISP)" only allows users to authenticate in Console from departments containing the string “NOC” or (|) from the “ISP” department

RADIUS server settings:

- **Priority** – You can set the order in which Console connects to multiple authentication services. The authentication process stops after the first successful authentication
- **Template User** – Remotely authenticated users without a Console account have the privileges of the Template User
- **RADIUS Host** – IP or hostname of the Radius server
- **RADIUS Port** – Port through which the Radius server is listening for authentication requests
- **RADIUS Protocol** – Protocol used for authentication purposes:
    - **PAP** (Password Authentication Protocol) – provides a simple method for the peer to establish its identity using a 2-way handshake
    - **CHAP** (Challenge-Handshake Authentication Protocol) – authenticates a user or network host to an authentication entity
    - **MSCHAP** – is the Microsoft version of the Challenge-handshake authentication protocol, CHAP
    - **MSCHAP2** – is another version of Microsoft version of the Challenge-handshake authentication protocol, CHAP
- **RADIUS Secret** – Enter the credentials for connecting to the Radius server.

The contents of the **Login Window Notification** field is shown inside the Console login window.

The contents of the **Successful Window Notification** field is shown inside the Console window after log in.

Reports » Tools » Anomalies

This report provides live and historical data related to DoS, DDoS, and other traffic anomalies. The number of active traffic anomalies is displayed inside the Reports » Tools panel. This number is refreshed every 10 seconds. The color of the number reflects the highest severity of the active anomalies.

The Anomalies tab contains 3 sub-tabs located at the lower left side of the window:

Active Anomalies

It shows a listing with active anomalies where each row represents an active anomaly. The columns are:

№	Unique index of the anomaly. Click it to open a detailed anomaly report
Prefix	The IP address/class subject of the traffic anomaly, and its reverse DNS. In front of the prefix, the arrow indicates the direction of traffic: inbound when the arrow is pointing towards the prefix, or outbound when the arrow is pointing away from the prefix. Click it to open a new tab or window with data specific to that prefix. A cloud icon located on the right of the prefix indicates that the IP is external, thus not included in the IP Zone
IP Group	The IP group of the prefix. Click it to open a new tab with data specific to that IP group
Anomaly	A short description of the anomaly
Speed (Latest)	The peak value of the abnormal traffic. The latest value is displayed between parentheses
Sensor Interface	On which Packet Sensor or Flow Sensor Interface the anomaly was detected. Click it to open a new tab with data specific to that Sensor Interface
From	The time and date when the anomaly started
Latest Alarm	How much time has passed since the most recent detection of the anomaly
Pkts/s – Bits/s	The latest packets/second and bits/second throughput of the IP decoder
Severity	The exact rule severity and link severity are displayed as a tool-tip. The rule severity field graphically represents the ratio between the abnormal traffic and the threshold value. Every bar represents 100% of the threshold value The color of the severity indicates the link's severity: 0-25% blue, 25%-50% yellow, 50%-75% orange, 75%-100% red. The link's severity is the ratio between the abnormal traffic and the overall traffic of the link (Sensor or interface) for pkt/s thresholds, or the ratio between the abnormal traffic and the link capacity for bits/s thresholds
Actions	Actions available for administrators, operators, and guests with proper permissions: • *Enable Manual Action(s)* – execute all actions configured for manual execution • *Classify/Set Comment* – add or modify comments, or manually classify the impact of anomalies. It is used only for reporting purposes and does not impact IP profiling • *View Live Graph* – available if IP Graphing is enabled for the prefix

	• *Open Packet Dump* – available for Packet Sensors when the Response contains a traffic capturing action • *Open Flow List* – available for Flow Sensors with the Flow Collector feature enabled Shows bi-directional flows that started or ended during the selected time interval. Flow listings may have an up to 5-minute delay due to flow data file buffering. Time zone differences are not adjusted • *Delete BGP Prefix* – available if a BGP announcement with the prefix exists • *Generate Anomaly Report* – generates a full anomaly report that can be viewed in a separate tab • *Expire Anomaly* – instructs the Sensor to clear the anomaly immediately, even if it's still active. The detecting Sensor must be running for the action to take effect
ADDITIONAL PARAMETERS VISIBLE WHEN DISPLAY IS SET TO "FULL":	
Total Pkts	Absolute number of packets counted since the anomaly started
Total Bits	Absolute number of bits counted since the anomaly started
Overall Traffic	Percentage value between the decoder traffic and the IP traffic
Threshold	Threshold value and unit
IP Zone (Inheritance)	IP Zone used by the detecting Sensor. Click it to open the most specific prefix settings
Template	Threshold Template containing the threshold rule, if any
Expiration	Seconds that must pass for the anomaly to be considered inactive
Response (Actions)	Name of the Response and a list of actions (with the Record Action parameter set) that were executed
Comments	This field is hidden if the *Classify/Set Comment* action was not used

When a Filter detects a filtering rule, a new table is displayed within the same row with the traffic anomaly. In most themes, the rows of the Filter table have a red background for active filtering rules and a yellow background for inactive filtering rules.

Filter	Name of the Filter that detected the filtering rule. Click it to open a new tab with Filter-specific data
Filtering Rule	A summary of the filtering rule detected to isolate the malicious traffic. The filtering rules that are enabled for the decoder are listed in Configuration » General Settings » Anomaly Mitigation A white flag within the same row indicates that the filtering rule conflicts with a whitelist rule, which also means that it was not applied to any Firewall
Started	Date and time when the filtering rule was generated
Latest Alarm	Latest time when the filtering rule matched traffic above the threshold value
Pkts/s (Peak)	Packets/second value for the traffic matching the filtering rule. In parentheses, peak pkts/s value
Bits/s (Peak)	Bits/second value for the traffic matching the filtering rule. In parentheses, peak bits/s value
Firewall	Indicates the firewall backend(s) that applied the filtering rule: • NetFilter Firewall • Dataplane Firewall

	• Hardware Offload • BGP Flowspec or S/RTBH • Third-party Firewall
Scrubbed	Percentage of abnormal traffic mitigated
Pkts	Absolute value with the packets matched by the filtering rule
Bits	Absolute value with the bits matched by the filtering rule
Actions	• *Open Packet Dump* – available for Packet Filters when the Response contains a traffic capturing action • *Open Flow List* – available for Flow Sensors with the Flow Collector feature enabled. Shows bi-directional flows that started or ended during the selected time interval. Flow listings may have a 5-minute delay due to flow file buffering. Time zone differences are not adjusted • *Expire Filtering Rule* – instructs the Filter to clear the filtering rule and the corresponding firewall rules immediately

Anomaly Archive

It lists all traffic anomalies sorted by time, in descending order. By clicking the down arrow on any column header, you can apply row filters, change sorting direction, or toggle the visibility of columns.

The [+] sign from the first column expands the anomaly for additional information, mitigation data, etc. The columns are explained in the previous section.

Anomaly Overview

Shows trends and summarizations of traffic anomalies detected on the selected Sensor Interfaces, using the selected decoders, for the selected time-frame.

Anomaly Distribution

Shows pie charts with various anomaly statistics.

Reports » Tools » Firewall

Reports » Tools displays the number of firewall rules that have new matches in the last 5 seconds.

The Firewall tab lists all firewall rules managed by Wanguard and provides a quick and easy way for Console users to define their own rules. The tab contains 3 sub-tabs, located at the lower left side of the window:

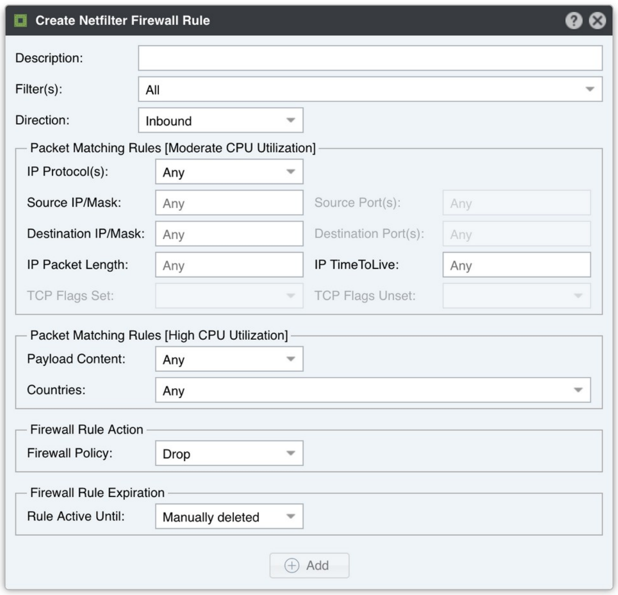
Active Firewall Rules

It displays the active rules generated automatically by Filters or introduced manually by Console users.

Administrators and operators can add and delete firewall rules manually. To add a new rule, click the [**Create Firewall Rule**] button and then choose one of the existing firewall options from the drop-down menu. The firewalls that are not defined in Filter configurations are hidden.

[**Reset All**] deletes all firewall rules from the GUI without actually updating the firewall's configuration.

The **Create Netfilter Firewall Rule** window provides the following options:


Create Netfilter Firewall Rule

Description:			
Filter(s):	All		
Direction:	Inbound		

Packet Matching Rules [Moderate CPU Utilization]

IP Protocol(s):	Any		
Source IP/Mask:	Any	Source Port(s):	Any
Destination IP/Mask:	Any	Destination Port(s):	Any
IP Packet Length:	Any	IP TimeToLive:	Any
TCP Flags Set:		TCP Flags Unset:	

Packet Matching Rules [High CPU Utilization]

Payload Content:	Any
Countries:	Any

Firewall Rule Action

Firewall Policy:	Drop

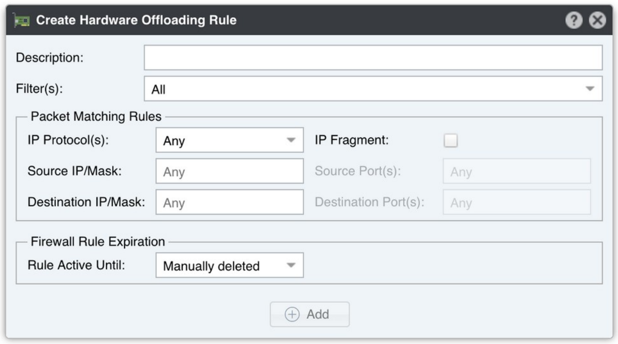
Firewall Rule Expiration

Rule Active Until:	Manually deleted

- **Description** – A short name that helps you identify the firewall rule. This is the only mandatory field
- **Filter(s)** – Select the Filter that will apply your rule (considering their configuration: interfaces, Netfilter Chain, Netfilter Table, etc.)
- **Direction** – Select *Inbound* to match packets entering your network (through interfaces defined as Inbound in the Filter Configuration window). Otherwise, select *Outbound*
- **IP Protocol(s)** – Select one or more IP protocols, or *Any* to match all packets

- **Source/Destination IP/mask** – Enter to match packets by their source or destination IP blocks. The mask is optional and values without it are considered hosts (mask defaults to /32 for IPv4 and /128 for IPv6)
- **Source/Destintation Port(s)** – This field is editable only for the following IP protocols: TCP, UDP, UDPLITE, DCCP, and SCTP. It matches a set of source or destination ports. Up to 15 ports can be specified (e.g. 53, 1024:65535 would match ports 53 and all from 1024 through 65535)
- **IP Packet Length** – It is used to match the length of the layer-3 payload (e.g. layer-4 packet) against a specific value or range of values separated by ":"
- **IP TimeToLive** – It is used to match the TTL field from the IP header. If the value is preceded by ">", then the packet is matched if TTL is greater than the given TTL value. If the value is preceded by "<", then the packet is matched if TTL is less than the given TTL value
- **TCP Flags Set/Unset** – Select the TCP flags that must be explicitly set and/or unset. TCP flags that are not enabled in either fields are ignored
- **Payload Content** – Enter to match a string anywhere in the packet. Use this option with caution as it consumes a lot of CPU resources
- **Country(ies)** – Select to match packets by their country of origin. This option can be used only after installing the *xp_geoip* Netfilter module
- **Firewall Policy** – Select the Netfilter Firewall policy applied for the matched packets:
    - Drop – blocks the packets
    - Reject – blocks packets and sends an ICMP reply packet indicating the port is unavailable
    - Accept – allows packets to pass the firewall
    - Rate Limit – allows a limited number of packets through the firewall
- **Rate Limit** – You can use this parameter to limit rate of packets per time unit to a predefined value. If the value ends with the character "b" then the rate-limiting is applied for bytes not packets
- **Rate Limit Hashing** – You can apply the rate-limiting globally, to a single object (*Src. IP*, *Src. Port*, *Dst. IP* or *Dst. Port*) or to any combination of objects. If the rate-limiting should be connection-oriented, select all objects. To rate-limit the packet or byte rate of each source IP, select the *Src. IP* object
- **Rule Active Until** – Select *Manually deleted* to apply the firewall rule indefinitely. Select the other options to remove the firewall rule after a predefined condition

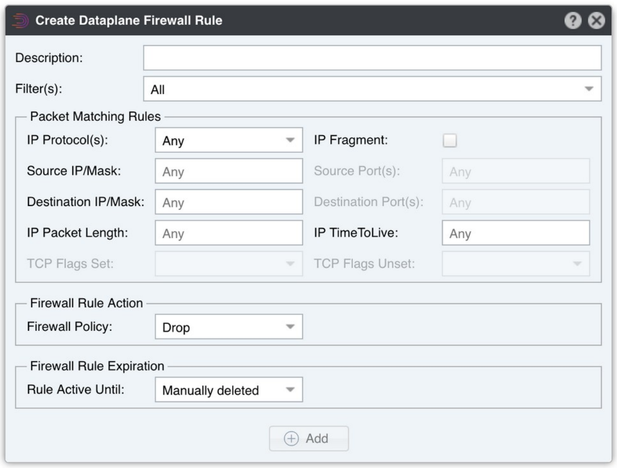
The **Create Hardware Offloading Rule** window contains the following options:



- **Description** – A short name that helps you identify the rule. This is the only mandatory field

- **Filter(s)** – Select the Filter that will apply your rule
- **IP Protocol(s)** – Select one or more IP protocols, or *Any* to match all packets
- **IP Fragment** – Select to match only fragmented packets
- **Source/Destination IP/mask** – Enter to match packets by their source or destination IP blocks. The mask is optional and values without it are considered hosts (mask defaults to /32 for IPv4 and /128 for IPv6)
- **Source/Destination Port(s)** – This field is available only for the following IP protocols: TCP, UDP, UDPLITE, DCCP and SCTP. It matches a set of source or destination ports. Up to 15 ports can be specified (e.g. 53, 1024:65535 would match ports 53 and all from 1024 through 65535)
- **Rule Active Until** – Select *Manually deleted* to apply the firewall rule indefinitely. Select the other options to remove the firewall rule after a predefined condition

The **Create Dataplane Firewall Rule** window contains fields that are already explained by the previous paragraph.


Create Dataplane Firewall Rule

Description:
Filter(s): All

Packet Matching Rules
IP Protocol(s): Any
IP Fragment:
Source IP/Mask: Any
Source Port(s): Any
Destination IP/Mask: Any
Destination Port(s): Any
IP Packet Length: Any
IP TimeToLive: Any
TCP Flags Set:
TCP Flags Unset:

Firewall Rule Action
Firewall Policy: Drop

Firewall Rule Expiration
Rule Active Until: Manually deleted

When there is at least one active firewall rule, a table describing it and showing the exact number of matches is displayed in the content area.

Filtering Rule Archive

Lists filtering rules detected by the selected Filter(s) for the selected time range. Most fields are described in the “Reports » Tools » Anomalies” chapter on page 75.

Filtering Rule Distribution

Creates pie charts with filtering rule statistics.

Reports » Tools » Routing

Reports » Tools displays the number of BGP announcements that are active. The number is red when there is at least one announcement sent through a BGP Connector configured for mitigation, or blue when all announcements were sent through BGP Connectors configured for traffic diversion.

The **Routing** tab displays all BGP announcements sent by Wanguard and provides a way for Console users to send BGP routing updates manually. The tab contains 3 sub-tabs, located at the lower left side of the window:

Active BGP Announcements

It displays all active BGP announcements sent by Sensors, Filters, Console users.

Console users can send or withdraw BGP announcements manually. To send an announcement, click the [**Create Blackhole**] or the [**Divert Traffic**] button and select a previously configured BGP Connector (see page 55) for mitigation or diversion.

[**Batch Actions**] - [**Clear**] marks all failed or orphaned announcements as finished.

[**Batch Actions**] - [**Resend**] resends all active announcements. Useful when ExaBGP loses its configuration.

[**Batch Actions**] - [**Reset**] marks all announcements as finished by manipulating the database directly, without actually using the BGP Connector.

When there is at least one active BGP announcement, the following information is displayed:

BGP Connector	BGP Connector used for the routing update. When Grouping is set to “BGP Connector”, clicking it allows you to delete all announcements that used it, with a single click
Role	Role configured for the BGP Connector. Can be *Unset*, *Mitigation* or *Diversion*
Prefix	The prefix contained in the BGP routing update. When Grouping is set to “IP/Mask”, clicking it allows you to delete all announcements for that prefix, with a single click
Status	A green check mark indicates that announcement was sent successfully. A red “X” icon indicates an error. Most errors are listed in the BGP Events (see page 69) grid. A warning sign indicates that the anomaly that triggered the announcement is no longer active, but the announcement still is. In this case you should remove the announcement manually and investigate the cause
Originator	Indicates the username of the Console user that sent the announcement, or the anomaly for which the announcement was generated. To avoid the overlapping of announcements, only a single announcement is sent to BGPd when there are multiple anomalies for the same prefix and BGP Connector
From	Time when the BGP announcement was sent
Until	Time when the BGP announcement will be withdrawn
Flowspec	Contains details about BGP Flowspec rules
Comments	Contains user comments about the BGP announcement

Actions	It contains a button for manual removal and a button for adding/modifying user comments. The column is hidden for guest accounts without proper permissions

BGP Announcement Archive

Lists all BGP announcements sent by Sensors, Filters and Console users. By clicking the down arrow of any column header, you can apply row filters, change sorting direction and toggle the visibility of columns. All columns are explained in the previous section, except for the Originating User column (hidden by default) that shows the Console user that sent and withdrew the announcement.

You can modify the status of announcements manually by double-clicking rows. The modification is applied only to the database, not to the Quagga BGPd/ExaBGP configuration.

BGP Connector Events

Lists events generated by BGP Connectors for the selected time range. Events are explained in the “Event Reporting” chapter on page 69.

Reports » Tools » Flows

Reports » Tools contains a link to the **Flows** item only when there is at least one Flow Sensor defined. Here you can list, aggregate, filter and sort flow records, or generate traffic tops and statistics.

There are 2 sub-tabs, located at the left lower side of the window:

Flow Records

Here you can list and filter flow data.

- **Sensor Interfaces** – Select the interfaces you are interested in. Administrators can restrict the interfaces visible by guest accounts
- **Flow Filtering Expression** – Here you can enter a filtering expression for flows. Click the star icon on the right to open a window that shows you the correct syntax. Frequently-used filtering expressions can be saved there and reused at any later time
- **Export** – If the output is not very large, it can be viewed, converted to PDF, emailed or printed. If you need to list huge amounts of flow data, doing it solely from the web browser may not be a good idea. In this case, select the "CLI" option to view the shell command used for flow listing. You can then execute the command from the shell and forward the output to a file
- **Time Range** – Select a predefined time range, or select "Custom..." to enter a specific time interval, in order to list flows that started or ended inside that interval. Time zone differences between the Console server and remote Flow Sensor servers are not adjusted automatically
- **Limit Flows** – Show only the first N flows
- **Output** – You can select several output formats, or you can type in your own format (the syntax is listed at the bottom of the Flow Filtering Expression help)
- **Aggregation** – By default, flows are not aggregated. By checking the appropriate options, you can select how to aggregate flows. You can aggregate entire subnets by selecting src(dst)IPv4(IPv6)/<subnet bits>
- **Sorting –** When listing flows sent from different interfaces, you can sort them after to the start time of the flows. Otherwise, flows are listed in the sequence of the selected interfaces

Flow Tops

Here you can generate tops from flow data.

- **Sensor Interfaces** – Select the interfaces you are interested in. Administrators can restrict the interfaces visible by guest accounts
- **Top Type** – Select the desired top type from the drop-down menu
- **Flow Filtering Expression** – Here you can enter a filtering expression for flows. Click the star icon on the

right to open a window that shows you the correct syntax. Frequently-used filtering expressions can be saved there and reused at any later time

- **Export** – If the output is not very large, it can be viewed, converted to PDF, emailed or printed. If you need to list huge amounts of top data, doing it solely from the web browser may not be a good idea. In this case, select the "CLI" option to view the shell command used for flow listing. You can then execute the command from the shell and forward the output to a file
- **Time Range** – Select a predefined time range, or select "Custom..." to enter a specific time interval, in order to count only flows that started or ended inside the interval. Time zone differences between the Console server and remote Flow Sensor servers are not adjusted automatically
- **Order By** – Select the sorting unit
- **Limit** – Limit the output to only those records whose packets or bytes match the specified condition
- **Top** – Limit the top listing to the first N records
- **Output** – You can select several output formats, or you can type in your own format (the syntax is listed at the bottom of the Flow Filtering Expression help)
- **Aggregation** – By default, flows are not aggregated. By checking the appropriate options, you can select how to aggregate flows. You can aggregate entire subnets by selecting src(dst)IPv4(IPv6)/<subnet bits>

Reports » Tools » Packets

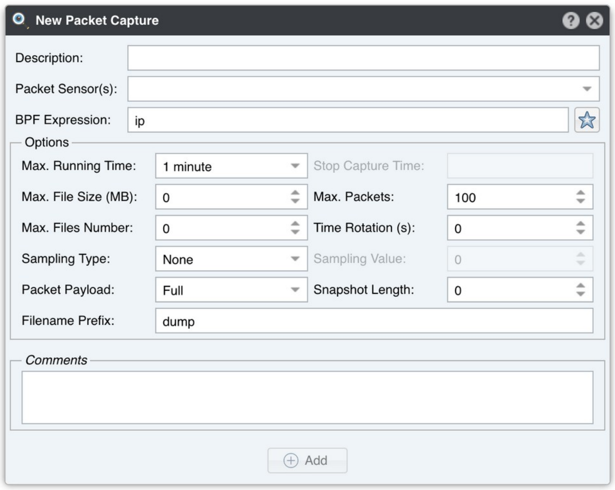
Reports » Tools contains a link to the **Packets** item only when there is at least one Packet Sensor or Packet Filter in use. The number of packet dumps (network trace, packet trace) that are active is displayed within the panel.

Here you can easily capture packets from Packet Sensors deployed on various parts of your network. You can view the content of packets directly from the user interface. Console provides an integrated packet analyzer that resembles the popular WireShark software.

There are 2 sub-tabs located at the lower left side of the window:

Active Packet Dumps

Administrators, operators, and guests with packet capturing privileges can generate packet dumps by clicking the [**Capture Packets**] button.



Description:			
Packet Sensor(s):			
BPF Expression:	ip		
Max. Running Time:	1 minute	Stop Capture Time:	
Max. File Size (MB):	0	Max. Packets:	100
Max. Files Number:	0	Time Rotation (s):	0
Sampling Type:	None	Sampling Value:	0
Packet Payload:	Full	Snapshot Length:	0
Filename Prefix:	dump		
Comments			

- **Description** – An optional short description to help you identify the packet dump
- **Packet Sensor(s)** – Select the Packet Sensor that will capture the packets. Administrators can restrict the Packet Sensors that are visible to guest accounts
- **BPF Expression** – Click the star icon on the right to open a window that describes the Berkley Packet Filter (BPF) syntax. Frequently used BPF expressions can be saved there and reused at a later time. Entering a BPF expression is mandatory. To capture all IP packets, enter "ip"
- **Max. Running Time** – Maximum running time of the capturing thread / process
- **Stop Capture Time** – When Max. Running Time is set to "Unlimited", you can set the exact time when the capturing thread stops
- **Max. File Size (MB)** – This option is used for splitting packet dumps into multiple files of <number> Mbytes. Before writing a raw packet to a file, Packet Sensor checks whether the file is currently larger than <number> and, if so, closes the current file and opens a new one

- **Max. Packets** – The capture stops after receiving <number> packets
- **Max. Files Number** – Setting this will limit the number of files created for the specified <number>, and begin overwriting files from the beginning, thus creating a "rotating" buffer. In addition, it will name the files with enough leading 0s to support the maximum number of files, allowing them to sort correctly
- **Time Rotation (s)** – If specified, this rotates the file every <number> seconds
- **Sampling Type & Value** – Select "None" when no packet sampling is required. Select "1 / Value" to save just one packet every <value> packets. Select "Value / 5s" to save up to <value> packets every 5 seconds
- **Packet Payload** – Select "Full" to capture the entire packet, "Only Layer 3" to zero-out the packet's payload except for the IP header, or "Only Layer 4" to retain only the TCP, UDP and ICMP headers
- **Snapshot Length** – Sniff <number> bytes of data from each packet rather than the default of 65535 bytes. Taking larger snapshots both increases the amount of time it takes to process packets and, effectively, decreases the amount of packet buffering. This may cause packets to be lost. You should limit this <number> to the smallest number that will capture the protocol information you are interested in
- **Filename Prefix** – Name of the packet dump file. If any file-rotation options are used, a number will be appended to the filename
- **Comments** – This field may contain comments about the packet dump

All active Packet Dumps are listed in a table having the following format:

- **Status** – Indicates the status of the capture process. It is green if it is running, and red if it is not
- **Packet Logger** – Packet Sensor or Packet Filter used for capturing the packets
- **Packets / Dropped** – Number of packets captured and number of packets dropped
- **Files / Size** – Number of dump files generated and the size of the latest dump file
- **Description [BPF]** – Description and the BPF expression used for the dump
- **From** – Date when the capture process started
- **Until** – Time limit or other conditions that will cause the capturing process to stop
- **Sampling** – Type of sampling being used
- **Payload** – The value of the "Packet Payload" parameter
- **Comments** – The value of the "Comments" parameter
- **Actions** – Click on the first icon to view the latest dump file in an integrated packet analyzer interface. Click on the second icon to download the latest dump file to your computer. If downloading does not work, but viewing does, increase the values of the *max_execution_time* and *memory_limit* from php.ini. Click the third icon to stop the capturing process

Packet Dump Archive

By default, the captures are sorted by time in descending order. By clicking the down arrow of any column header, you can apply row filters, change sorting direction and toggle the visibility of columns.

The [+] sign from the first column expands each row for additional information about the capture and provides access to packet dump files. The columns are explained in the previous section.

Reports » Devices » Overview

Here you can see the most important operational parameters collected in realtime from all active Wanguard components and servers:

The **Console** table displays the following data:

Status	A green check mark indicates that Console is functioning properly. When a red "X" appears, enable the WANsupervisor service on the Console server
Online Users	Active Console sessions
Avg. DB Bits/s (In/Out)	Average number of bits/s sent and received since the start of the database
Avg. DB Queries/s	Average number of queries per second since the start of the database
DB Clients	DB clients that are currently using the database
DB Connections	Active connections to the database
DB Size	Disk space used by the database
Free DB Disk	Disk space available on the partition configured to store the Console database
Free Graphs Disk	Disk space available on the partition configured to store IP graphs
Time Zone	Time zone of the Console server
Console Time	The clock from the Console server
Uptime	Uptime of the database

The **Servers** table displays the following data for each server that runs software components of Wanguard:

Status	A green check mark indicates that the server is connected to the database. When a red "X" is displayed, start the WANsupervisor service and make sure that the clock from the Console server is synchronized with the clock from the remote server
Server Name	Displays the name of the server and the associated color. Click to open a new tab with data specific to the server. Administrators and operators can right-click to open the Server Configuration window
Load	Load average reported by the Linux kernel for the last 5 minutes
Free RAM	Available RAM. Swap memory not counted
CPU% User	Percentage of CPU resources used by the user space processes. Can be >100% on multiple cores/CPUs (e.g. the maximum value for a quad-core system is 400%)
CPU% System	Percentage of CPU resources used by the kernel. Can be >100% on multiple cores/CPUs (e.g. the maximum value for a quad-core system is 400%)

CPU% IOwait	Percentage of CPU resources waiting for I/O operations to complete. A high number indicates an I/O bottleneck
CPU% Idle	Percentage of idle CPU resources. Can be >100% on multiple cores/CPUs (e.g. the maximum value for a quad-core system is 400%)
Free Flows Disk	Disk space available on the partition that is configured to store flows
Free Dumps Disk	Disk space available on the partition that is configured to store packet dumps
Contexts/IRQs/SoftIRQs	Context switches, hardware interrupts and software interrupts per second
Uptime	Uptime of the operating system

The **Sensor Clusters** table displays the following data when there is at least one Sensor Cluster active:

Status	A green check mark indicates that the Sensor Cluster is connected to the database. If you see a red “X” instead, make sure that the WANsupervisor service is running and look for errors in the event log (see page 69)
Sensor Name	Displays the name of the Sensor Cluster and the associated color. Click to open a new tab with data specific to the Sensor Cluster. Administrators and operators can right-click to open the Sensor Cluster configuration window
Pkts/s (In / Out)	Inbound and outbound packets/second throughput
Inbound Bits/s	Inbound bits/second throughput and the usage percent
Outbound Bits/s	Outbound bits/second throughput and the usage percent
Received Pkts/s	Packet/s reported by the associated Sensors
IPs (Int./Ext.)	Number of IP addresses that sent or received traffic. The Int(ernal)/Ext(ernal) IPs are the IPs from inside/outside the IP Zone. The Stats Engine parameter from the associated Sensors’ configurations enables or disables the monitoring of external IPs
Dropped	Packets dropped by the Server Cluster
CPU%	Percentage of CPUs used by the process
RAM	Amount of memory used by the process
Start Time	Time when the Sensor Cluster instance started
Server	Which server runs the Sensor Cluster. Click to open a tab with specific data. Administrators and operators can right-click to open the Server Configuration window

The **Packet Sensors** table displays the following data when there is at least one Packet Sensor active:

Status	A green check mark indicates that the Packet Sensor is connected to the database. If you see a red “X” instead, make sure that the WANsupervisor service is running and look for errors in the event log (see page 69)
Sensor Name	Displays the name of the Packet Sensor and the associated color. Click to open a new tab with specific information. Administrators and operators can right-click to open the Packet

	Sensor Configuration window
Pkts/s (In / Out)	Inbound and outbound packets/second throughput after IP or MAC validation
Inbound Bits/s	Inbound bits/second throughput after IP / MAC Validation, and the usage percent
Outbound Bits/s	Outbound bits/second throughput after IP / MAC Validation, and the usage percent
Received Pkts/s	Rate of sniffed packets before IP / MAC Validation
IPs (Int / Ext)	IP addresses that sent or received traffic. The Int(ernal)/Ext(ernal) IPs are the IPs from inside/outside the IP Zone. The Stats Engine parameter from the Sensor configuration enables or disables the monitoring of external IPs
Dropped	Packets dropped by the packet capturing engine. A high number usually indicates a sniffing performance problem
CPU%	Percentage of CPUs used by the process
RAM	Amount of memory used by the process
Start Time	Time when the Packet Sensor started
Server	Which server runs the Packet Sensor. Click to open a tab with specific data. Administrators and operators can right-click to open the Server Configuration window

The **Flow Sensors** table displays the following data when there is at least one Flow Sensor active:

Status	A green check mark indicates that the Flow Sensor is connected to the database. If you see a red “X” instead, make sure that the WANsupervisor service is running and look for errors in the event log (see page 69)
Sensor Name	Displays the name of the Flow Sensor. Click to open a new tab with specific data. Administrators and operators can right-click to open the Flow Sensor Configuration window
Interface	Interface name and the associated color. If the interface names are missing for more than 5 minutes after the Flow Sensor has started, check the troubleshooting guide from page 48
Pkts/s (In / Out)	Inbound and outbound packets/second throughput after IP / AS Validation
Inbound Bits/s	Inbound bits/second throughput after IP / AS Validation, and usage percent
Outbound Bits/s	Outbound bits/second throughput after IP / AS Validation, and usage percent
IPs (Int / Ext)	IP addresses that send or receive traffic. The Int(ernal)/Ext(ernal) IPs are the IPs from inside/outside the IP Zone. The Stats Engine parameter from the Sensor configuration enables or disables the monitoring of external IPs
Flows/s	Flows per second received by the Flow Sensor
Flows Delay	Because traffic data must be aggregated, flow devices export flows with a configured delay. Some devices export flows much later than the configured delay and this field contains the maximum flows delay detected by the Flow Sensor. Flow Sensor cannot run with flow delays higher than 5 minutes
Dropped	Unaccounted flows. A high number indicates a performance problem of the Flow Sensor or a network connectivity issue with the flow exporter
CPU%	Percentage of CPU resources used by the Flow Sensor process

RAM	Amount of RAM used by the Flow Sensor process
Start Time	Time when the Flow Sensor started
Server	Which server runs the Flow Sensor. Click to open a tab with specific data. Administrators and operators can right-click to open the Server Configuration window

The **SNMP Sensors** table displays the following data when there is at least one SNMP Sensor active:

Status	A green check mark indicates that the SNMP Sensor is connected to the database. If you see a red “X” instead, make sure that the WANsupervisor service is running and look for errors in the event log (see page 69)
Sensor Name	Displays the name of the SNMP Sensor. Click to open a new tab with specific data. Administrators and operators can right-click to open the SNMP Sensor Configuration window
Interface	Interface name and the associated color
Pkts/s (In / Out)	Inbound and outbound packets/second throughput
Inbound Bits/s	Inbound bits/second throughput and usage percent
Outbound Bits/s	Outbound bits/second throughput and usage percent
Errors/s (In / Out)	For packet-oriented interfaces, it represents the number of inbound and outbound packets that contained errors, preventing them from being deliverable to a higher-layer protocol. For character-oriented or fixed-length interfaces, it represents the number of inbound transmission units that contained errors preventing them from being deliverable to a higher-layer protocol
Discards/s (In / Out)	Discarded inbound and outbound packets even though no errors were detected to prevent them from being deliverable to a higher-layer protocol. One possible reason for discarding such a packet could be to free up buffer space
Oper. Status	Current operational state of the interface. The *Testing* state indicates that no operational packets can be passed. If Administrative Status is *Down* then Operational Status should be *Down*. If Administrative Status is changed to *Up* then Operational Status should change to *Up* if the interface is ready to transmit and receive network traffic; it should change to *Dormant* if the interface is waiting for external actions (such as a serial line waiting for an incoming connection); it should remain in the *Down* state if and only if there is a fault that prevents it from going to the *Up* state; it should remain in the *NotPresent* state if the interface has missing (typically, hardware) components
Admin. Status	Desired state of the interface. The *Testing* state indicates that no operational packets can be passed. When a managed system initializes, all interfaces start with the Administrative Status in the *Down* state. As a result of either explicit management action or per configuration information retained by the managed system, the Administrative Status is then changed to either the *Up* or *Testing* states (or remains in the *Down* state)
CPU%	Percentage of CPU resources used by the process
RAM	Amount of RAM used by the process
Start Time	Time when the SNMP Sensor started

Server	Which server runs the SNMP Sensor. Click to open a tab with specific data. Administrators and operators can right-click to open the Server Configuration window

The **Filter Clusters, Packet Filters, and Flow Filters** table displays the following data:

Status	A green check mark indicates that the Filter is connected to the database. If you see a red “X” instead, make sure that the WANsupervisor service is running and look for errors in the event log (see page 69)
Filter Name	Displays the Filter and the associated color. Click to open a new tab with specific data. Administrators and operators can right-click to open the Filter Configuration window
Anomaly №	When a Filter instance is activated by a Response to mitigate an anomaly, the field contains the link to the anomaly report. Otherwise, the field contains the message “No active instance”, which is not an error
Prefix	IP address/mask of your network that is originating or being the target of the attack. Click to open a tab with specific data
IP Group	IP group of the prefix. Click to open a tab with data specific to the IP group
Decoder	Decoder used for detecting the abnormal traffic
Pkts/s	Packets/second throughput sent to the attacked prefix
Bits/s	Bits/second throughput sent to the attacked prefix
IPs (Ext.)	Number of IP addresses sending traffic to the attacked prefix
Dropped	Rate of packets dropped by the packet capturing engine. A very high number indicates a performance problem related to packet sniffing
Peak CPU%	Maximum percentage of CPU resources used by the Filter instance
Peak RAM	Maximum amount of RAM used by the Filter instance
Start Time	Time when the Filter instance started mitigating the anomaly
Server	Which server runs the Filter instance. Click to open a tab with specific data. Administrators and operators can right-click to open the Server Configuration window

Reports » Devices » Sensors

Clicking on a Sensor opens a tab with specific information. The tab includes a few sub-tabs located at the lower side of the window. All sub-tabs share the following common toolbar fields:

- **Sensor Interfaces** – Select the Sensor interfaces you are interested in, or select "All". Administrators can restrict which Sensors are accessible by guest accounts
- **Time Range** – Select a predefined time range, or select "Custom..." to enter a specific time interval

Sensor Dashboard

This tab allows you to view the most relevant data collected by Sensors in form of widgets. The configuration of the Sensor Dashboard does not apply to a particular Sensor, so the changes you make here are visible for other Sensor Dashboards as well. The operation of dashboards is described in the "Reports » Dashboards" chapter on page 99.

The configuration of Sensor widgets is outlined in the following paragraphs.

Sensor Graphs

This sub-tab allows you to view a variety of Sensor-related histograms for the selected Sensor Interface(s):

- **Data Units** – Select one or more data units:
  - *Most Used* – Frequently-used data units
  - *Packets* – Inbound packets/second (+ on Y-axis) and outbound packets/second (- on Y-axis)
  - *Bits* – Inbound bits/second (+ on Y-axis) and outbound bits/second (- on Y-axis)
  - *Applications* – Sensor can collect application-specific distribution data for HTTP, HTTPS, SMTP, POP3, IMAP, SNMP, FTP, SSH, TELNET, SQL, NETBIOS, MS-DS, MS-RDP, DNS, ICMP, and OTHERS. These graphs are not generated when the Sensor's Stats Engine parameter is set to "Disabled"
  - *Internal & External IPs* – Number of IP addresses that send or receive traffic. The "internal" and "external" IPs are the hosts located inside or outside the IP Zone. The Sensor's "Stats Engine" parameter enables or disables monitoring of external IPs. A spike in the Internal IPs graph usually means that an IP class scan was performed against your IP blocks. A spike in the external IPs graph usually means that you have received a spoofed attack
  - *Received Frames* – For Packet Sensor, it represents the number of packets/s received before IP or MAC validation. For Flow Sensor, it represents the number of flows/s received before IP or AS validation
  - *Dropped Frames* – For Packet Sensor, it represents the number of packets dropped by the packet capturing engine. A high number indicates a sniffing performance problem. For Flow Sensor, it represents the number of unaccounted flows. A high number indicates a wrong configuration or a network connectivity issue with the flow exporter

- ◦ *Unknown Frames* – For Packet Sensor, it represents the rate of packets not passing IP validation. For Flow Sensor, it represents the rate of invalidated flows
- ◦ *Unknown Sources – S*ource IP addresses that did not pass IP validation
- ◦ *Unknown Destinations* – Destination IP addresses that did not pass IP validation
- ◦ *Avg. Packet Size* – Average packet size in bits/packet
- ◦ *CPU%* – Percentage of CPU resources used by the Sensor process
- ◦ *RAM* – Amount of RAM used by the Sensor process
- ◦ *Load* – Load reported by the Linux kernel for 5 minute intervals
- ◦ *IP Graphs* – Number of IP graphs files updated
- ◦ *IP Accounting* – Number of IP accounting records updated
- ◦ *Profile Graphs* – Number of profiling files updated
- ◦ *IP Graphs Time* – Seconds needed to update the IP graphs files
- ◦ *Profile Graphs Time* – Seconds needed to update the profiling files
- ◦ *Processing Time* – Seconds needed to perform traffic analysis functions
- ◦ *IP Structures* – Number of Internal IP structures necessary to keep track of IPs
- ◦ *IP Structure RAM* – RAM bytes used by each IP structure
- ◦ *Dataplane* – Parameters collected from the DPDK-based Capture Engine
- ◦ *Bytes/time unit* – Bytes/<time unit> throughput value

- **Size** – Select a predefined graph dimension or enter a custom one in "<X> x <Y>" format, where <X> and <Y> are the X-axis and Y-axis pixels
- **Title** – Graphs have an automatically-generated title for the "Auto" option, no title for the "None" option, or you can enter your own text to be rendered as a title
- **Legend** – Select the level of detail for the graph's legend
- **Consolidation** – If you are interested in spikes, choose the *MAXIMUM* aggregation type. If you are interested in average values, choose the *AVERAGE* aggregation type. If you are interested in low values, choose the *MINIMUM* aggregation type
- **Grouping**
  - ◦ **Sensor Interfaces** – Select to generate a single graph for the Sensor Interfaces selected
- **Stacking**
  - ◦ **Sensor Interfaces** – Select to view the summed up, stacked values for multiple Sensor Interfaces

Sensor Tops

This sub-tab allows you to generate various traffic tops per Sensor Interface. The Stats Engine parameter from the Sensor configuration manages the collection of various Sensor tops.

- **Decoders** – Select the decoder that analyzes the type of traffic that interests you
- **Top Unit** – Select a top type:

- ○ *Talkers* – Hosts from your network that sent or received the most traffic for the selected decoder. Not available when the Stats Engine parameter from the Sensor configuration is set to "Disabled"
- ○ *IP Groups* – IP groups that sent or received the most traffic for the selected decoder. Not available when the Stats Engine parameter from the Sensor configuration is set to "Disabled"
- ○ *External IPs* – External IPs that sent or received the most traffic for the selected decoder. Available when the Stats Engine parameter from the Sensor configuration is set to "Extended" or "Full"
- ○ *Autonomous Systems* – Autonomous systems that sent or received the most traffic. Available only when the Stats Engine parameter from the Sensor configuration is set to "Extended" or "Full"
- ○ *Transit Autonomous Systems* – Transit autonomous systems that sent or received the most traffic. Available only when the Sensor is configured to extract Transit AS data from a BGP dump file
- ○ *Countries* – Countries that sent or received the most traffic. Available only when the Stats Engine parameter from the Sensor configuration is set to "Extended" or "Full"
- ○ *TCP Ports* – Most-used TCP ports. Not available when the Stats Engine parameter from the Sensor configuration is set to "Disabled"
- ○ *UDP Ports* – Most-used UDP ports. Not available when the Stats Engine parameter from the Sensor configuration is set to "Disabled"
- ○ *IP Protocols* – Most-used IP protocols (the protocol used in the data portion of the IP datagram). Not available when the Stats Engine parameter from the Sensor configuration is set to "Disabled"
- ○ *IP Versions* – Counters for IPv4 traffic and IPv6 traffic. Not available when the Stats Engine parameter from the Sensor configuration is set to "Disabled"

- **Traffic Direction** – Direction of traffic, *All*, *Inbound* or *Outbound*
- **Display Options** – Various display options
- **Grouping**
  - **Sensor Interfaces** – When unchecked, a different top is generated for each selected Sensor Interface. When checked, top data is combined

You can increase the number of top records and add new decoders in Configuration » General Settings » Graphs & Storage, see page 22.

Generating tops for many Sensor Interfaces and for long time ranges may take minutes. If the report page timeouts, increase the *max_execution_time* parameter from *php.ini*.

Sensor Events

This sub-tab lists events generated by the selected Sensor(s) for the selected time range. The events are described in the "Event Reporting" chapter on page 69.

Anomaly Overview

This sub-tab displays trends and summarizations of the anomalies detected by the selected Sensor Interfaces.

AS Graphs

Flow Sensor and Packet Sensor can generate per-autonomous system bandwidth histograms. This feature is enabled for Packet Sensor when the Stats Engine parameter is set to “Full”, and for Flow Sensor when the Stats Engine parameter is set to “Full” or “Extended”.

The inbound traffic represents the traffic received by the AS, while the outbound traffic represents the traffic sent from the AS.

- **AS Number(s)**

  Select one of the following options:

  - *Upstream* – Select to see the traffic sent to or coming from the Autonomous Systems from the list on the right
  - *Transit* – Select to see the traffic that transited the Autonomous Systems from the list on the right
  - *Peering* – Select to see traffic to/from your AS peers (PrevAdjacentAS and NextAdjacentAS in NetFlow v9) from the list on the right
  - *Downstream* – Select to see the traffic to/from your downstream Autonomous Systems from the list on the right

  Click the star icon on the right to open a window containing the correct syntax for the AS list. Frequently-searched AS numbers can be saved there, and used at a later time. To see a list of AS numbers owned by a particular organization, go to Help » IP & AS Information » AS Numbers List or consult https://bgp.he.net
- **Size** – Select a predefined graph dimension or enter a custom one in a “<X> x <Y>” format, where <X> and <Y> are the X-axis and Y-axis pixels
- **Title** – Graphs have an automatically-generated title for “Auto”, no title for “None”, or you can enter your own text to be rendered as a title
- **Legend** – Select the level of detail for the graph’s legend
- **Grouping**
  - **Sensor Interfaces** – When unchecked, a different graph is generated for each selected Sensor Interface. When checked, the data is combined
  - **ASNs** – Select if you want to view a single graph for multiple AS numbers
- **Stacking**
  - **ASNs** – Select to stack up to 20 ASNs into a single graph

Country Graphs

Flow Sensor and Packet Sensor can generate per-country bandwidth histograms. This feature is enabled when the Sensor’s Stats Engine parameter is set to “Full” or “Extended”.

- **Countries** – Select the country or countries from the drop-down list, or click the star icon on the right to open a window with saved selections for continents and world regions
- **Size** – Select a predefined graph dimension or enter a custom one in a “<X> x <Y>” format, where <X> and

<Y> are the X-axis and Y-axis pixels

- **Title** – Graphs have an automatically-generated title for “Auto”, no title for “None”, or you can enter your own text to be rendered as a title
- **Legend** – Select the level of detail for the graph’s legend
- **Grouping**
  - **Sensor Interfaces** – Select to generate a single graph for the selected Sensor Interfaces
  - **Countries** – Select to view a single graph when multiple countries are selected
- **Stacking**
  - **Countries** – Select to stack up to 20 countries into a single graph

Flow Records

You can list and filter the flow data collected for the selected Flow Sensor Interfaces. The options are described in detail by the “Flow Collectors” chapter on page 83.

Flow Tops

You can generate tops from the flow data collected for the selected Sensor Interfaces. The options are described in detail in the “Flow Collectors” chapter on page 83.

Reports » Devices » Filters

Clicking on a Filter opens a tab with specific information. The tab includes a few sub-tabs located at the lower side of the window. All sub-tabs share the following common toolbar fields:

- **Filters** – Select the Filters you are interested in, or select "All". Administrators can restrict which Filters are accessible by guest accounts
- **Time Range** – Select a predefined time range, or select "Custom..." to enter a specific time interval

Filter Dashboard

This tab allows you to view the most relevant data collected by Filters in form of widgets. The configuration of the Sensor Dashboard does not apply to a particular Filter, so the changes you make here are visible for other Filter Dashboards as well. The operation of dashboards is described in the "Reports » Dashboards" chapter on page 99.

The configuration of Filter widgets is outlined in the following paragraphs.

Filter Graphs

This sub-tab allows you to view a variety of Filter-related histograms for the selected Filter(s):

- **Data Units** – Select one or more data units:
  - *Most Used* – Frequently-used data units
  - *Anomalies* – Anomalies mitigated by the selected Filter(s)
  - *Filtering Rules* – Filtering rules detected by the selected Filter(s)
  - *SW Firewall Rules* – Filtering rules applied by the software firewall framework
  - *HW Firewall Rules* – Filtering rules applied by the hardware firewall framework
  - *Source IPs* – Unique IP addresses that have sent traffic to the attacked destination(s)
  - *CPU%* – Maximum percentage of CPU resources used by the selected Filter(s)
  - *Used RAM* – Amount of RAM used by the selected Filter(s)
  - *Filtered Packets* – How many packets were reported as blocked
  - *Filtered Bits* – How many bits were reported as blocked
  - *Dropped Packets* – Rate of packets dropped by the packet capturing engine of the selected Filter(s)
  - *Received Packets* – Rate of packets received by the selected Filter(s)
  - *Packets/s* – Rate of packets analyzed by the selected Filter(s)
  - *Bits/s* – Rate of bits analyzed by the selected Filter(s)
  - *Filtering Rules* – Filtering rules found for each filtering rule type

  - *Total Excepted Rules* – Whitelisted filtering rules
- **Size** – Select a predefined graph dimension or enter a custom one in a "<X> x <Y>" format, where <X> and <Y> are the X-axis and Y-axis pixels
- **Title** – Graphs have an automatically-generated title for "Auto", no title for "None", or you can enter your own text to be rendered as a title
- **Legend** – Select the level of detail for the graph's legend
- **Consolidation** – If you are interested in spikes, choose the *MAXIMUM* aggregation type. If you are interested in average values, choose the *AVERAGE* aggregation type. If you are interested in low values, choose the *MINIMUM* aggregation type
- **Grouping**
  - **Filters** – Select to generate a single graph for the selected Filters
- **Stacking**
  - **Filters** – Select to view the summed up, stacked values for multiple Filters

Filter Events

Lists events generated by the selected Filter(s) for the selected time range. The events are described in the "Event Reporting chapter" on page 69.

Filter Instances

Lists statistics collected by each Filter instance.

Filtering Rules Archive

Lists filtering rules detected by the selected Filter(s) for the selected time range. Most fields are described in the "Reports » Tools » Anomalies" chapter on page 75.

Filtering Rules Distribution

Generates pie charts with various statistics related to filtering rules.

Reports » Dashboards

Wouldn't it be nice to see all the relevant data in a single tab? **Dashboards** allow you to group data from any report according to your needs.

Any dashboard can be configured to refresh all its widgets, flicker-free, at intervals ranging from 5 seconds to 15 minutes.

A few sample dashboards are included by default. If you are a Console administrator or operator you can **create** and configure your own dashboards by clicking Reports » Dashboards » [+] button from the panel's title. Guest accounts are not allowed to add or make modifications to dashboards.

In the dashboard **configuration**, you can edit the name of the dashboard, set permissions, layout, or choose to override the time range of widgets with the time range of the dashboard.

Each dashboard contains **widgets**. To sort them, click the title bar and move them around. To collapse a widget, click the first icon on the widget title bar. To configure a widget, click the second icon from its title bar. To delete a widget, click the third icon from its title bar.

Along with a few specific fields, every widget has a configurable title and height. Leave the widget's height parameter set to "Auto" for the widget to take all the vertical space it needs. To restrict the height of a widget, enter a number of pixels instead.

Widget options are self-explanatory or described in other chapters.

Reports » IP Addresses & Groups

This chapter describes how to generate detailed traffic reports for any IP address, block or group included in Configuration » Network & Policy » [IP Zone].

Reports » IP Addresses allows you to quickly generate traffic reports for IP addresses and blocks, either entered manually on the upper side of the panel, or selected from the expandable tree below.

Reports » IP Groups lists IP groups defined in IP Zones. Select an IP group to generate a traffic report for all IP blocks belonging to it. To search for a specific IP group, enter a sub-string contained in its name on the upper side of the panel.

The traffic report tab includes a few sub-tabs located on the lower side of the window. All sub-tabs share the following common toolbar fields:

- **Sensor Interfaces** – Select the Sensor Interfaces you are interested in. Administrators can restrict the Sensors accessible by guest accounts
- **Time Range** – Select a predefined time range, or select “Custom...” to enter a specific time interval

IP Dashboard

Here you can group the most relevant data collected for the selected Sensor Interfaces and for the selected IP address, block or group. The configuration of this dashboard does not apply to a particular IP address, block or group, so the changes you make will be visible for other IP dashboards as well. The operation of dashboards is described in the “Reports » Dashboards” chapter on page 99.

IP Graphs

You can generate IP graphs only for the IP addresses, blocks and groups specifically defined in your IP Zone(s), or that belong to a subnet having the IP Graphing parameter set to “Yes”.

- **Decoders & Data Unit** – Select the decoders and data unit you are interested in
- **Size** – Select a predefined graph dimension or enter a custom one in a “<X> x <Y>” format, where <X> and <Y> are the X-axis and Y-axis pixels
- **Title** – Graphs have an automatically-generated title for “Auto”, no title for “None”, or you can enter your own text to be rendered as a title
- **Legend** – Select the detail of the graph’s legend
- **Consolidation** – If you are interested in spikes, choose the *MAXIMUM* aggregation type. If you are interested in average values, choose the *AVERAGE* aggregation type. If you are interested in low values, choose the *MINIMUM* aggregation type
- **Direction** – Generates a graph for both directions, swap inbound (+ Y axis) with outbound (- Y axis), or show only inbound or outbound traffic

- **Grouping**
    - **Sensor Interfaces** – Generates a single graph for the selected Sensor Interfaces
    - **Subnet IPs** – Uncheck this option if you want a different traffic graph displayed for every IP address contained in the selected IP block or IP group. Do not uncheck this option on large subnets
- **Stacking**
    - **Decoders** – Select to view the summed up, stacked values for the selected decoders
    - **Sensor Interfaces** – Select to view the summed up, stacked values for multiple Sensor Interfaces
- **Permissions**
    - **Decoder Conflict** – If decoders can be included one within the other (e.g. IP contains TCP which contains HTTP and HTTPS), the graph will display stacked decoders to show the most specific ones. This generates both accurate and intuitive traffic graphs. In the example above, IP will be displayed as IP OTHER and TCP as TCP OTHER. However, when you select TCP, HTTP and TCP+SYN as decoders, the TCP+SYN decoder can be included in both TCP and HTTP, thus generating a decoder conflict. Check this option to stop detection of conflicting decoders, in order to generate more intuitive but potentially inaccurate traffic graphs
    - **Use Per-IP Data** – Creates a subnet graph by aggregating the IP graph data generated for every IP address contained in the selected IP block or group. This option will increase the load of the server if used frequently on large subnets. Use this option carefully, only when the IP block or group is not explicitly defined in the IP Zone but it is included in a larger subnet defined with the IP Graphing parameter set to “Yes”

The decoders, data units, and aggregation types can be modified in Configuration » General Settings » Graphs & Storage (see page 22).

IP Accounting

You can generate IP accounting reports only for the IP addresses, blocks and groups specifically defined in your IP Zone(s), or that belong to a subnet that has the IP Accounting parameter set to “Yes”.

- **Decoders & Data Unit** – Select the decoders and data unit that you are interested in
- **Report Interval** – Select the minimum interval used to aggregate the accounting data: *Daily*, *Weekly*, *Monthly*, *Yearly*. The minimum accuracy of traffic accounting reports is 24 hours, therefore when you select a shorter time range you will still see the accounting data collected for the whole day
- **Direction** – Show both directions or only a single one
- **Group Sensor Interfaces** – Generates a single traffic accounting report for multiple Sensor Interfaces
- **Show IPs** – Check this option for the traffic accounting report to display each IP address contained in the selected IP block or group. Selecting this option also enables the option below
- **Use Per-IP Data** – Creates a traffic accounting report by aggregating the IP accounting data generated for every IP address contained in the selected IP block or group. This option will increase the load of the server if used frequently on large subnets. Use this option carefully, only when the selected IP block or group is not explicitly defined in the IP Zone but it is included in a larger subnet defined with the IP Accounting parameter set to “Yes”

- **Display Raw Values** – Check this option to avoid displaying values with metric prefixes

The decoders can be modified in Configuration » General Settings » Graphs & Storage (see page 22).

Anomaly Overview

Here you can generate a report with trends and summarizations of traffic anomalies sent or received by the selected IP address, block or group.

Profile Graphs

Here you can view traffic profiling graphs generated for the selected IP block or host. Traffic profiling can be globally disabled from Configuration » General Settings » Anomaly Detection (see page 28). Sensor generates traffic profiling graphs only for IP blocks or hosts that have the Profiling Data parameter in the IP Zone set to "Subnet", "IPs" or "Subnet + IPs".

Flow Records

You can list and filter the flow data collected for the selected Flow Sensor Interfaces and IP block, host or group. The options are described in detail by the "Flow Collectors" chapter on page 83.

This sub-tab is visible only when there is at least one Flow Sensor in use.

Flow Tops

You can generate tops from the flow data collected for the selected Flow Sensor Interfaces and IP block, host or group. The options are described in detail by the "Flow Collectors" chapter on page 83.

This sub-tab is visible only when there is at least one Flow Sensor in use.

Reports » Servers

Click on a server name anywhere in the user interface to open a tab containing server-specific information. This tab includes a few sub-tabs, located at the lower side of the window. All sub-tabs share the following common toolbar fields:

- **Servers** – Select the servers you are interested in, or select "All". Administrators can restrict the servers available to guest accounts
- **Time Range** – Select a predefined time range, or select "Custom..." to enter a specific time interval

Console / Server Dashboard

Allows you to group the most relevant server-related data. The configuration for this dashboard does not apply to a particular server, so the changes you make will be visible for other server dashboards as well. The operation of dashboards is described in the "Reports » Dashboards" chapter on page 99.

The configuration of Server and Console widgets is described in the following paragraphs.

Console / Server Graphs

Server Graphs allows you to generate various histograms for the selected server(s):

- **Data Units** – Select one or more data units:
  - *Most Used* – Frequently-used data units
  - *System Load* – Load reported by the Linux kernel for a 5 minute period
  - *Free RAM* – Available RAM. Swap memory is not counted
  - *Database/Graphs/SSD/Flow Collector/Packet Dumps Disk - Free space* – How much disk space is available for each file-system path
  - *Uptime* – Uptime of the operating system
  - *CPU% system/userspace/niced/idle* – Percentages of CPU resources used by the system, userspace processes, processes running with increased (nice) priority, and idle loop
  - *Number of processes* – Total number of processes that are running
  - *Hardware/Software CPU Interrupts* – CPU interrupts made by hardware and software events
  - *Context Switches* – Indicates how much time the system spends on multi-tasking
  - *Running Components* – Sensor and Filter instances
  - *Clock Delta* – Difference of time between the selected server and the Console server, in seconds. If the value is not zero run ntpd to keep the clock synchronized on all servers
  - *Database/Graphs/SSD/Packet Dumps/Flow Collector Disk - Total* – How much disk space is allocated for the partitions that store the paths

  - *Database/Graphs/SSD/Packet Dumps/Flow Collector Disk - Free Inodes* – Free inodes held by the partitions that store the paths
  - *Database/Graphs/SSD/Packet Dumps/Flow Collector Disk - Ops/s* – Reads and writes made on the partitions that store the paths
  - *Database/Graphs/SSD/Packet Dumps/Flow Collector Disk - Bytes/s* – Bytes/s on the partitions that store the paths
  - *Server Interface(s) - Packets/Bits/Errors/Dropped* – Interface statistics collected for the network interfaces defined in the Configuration » Servers
- **Size** – Select a predefined graph dimension or enter a custom one in a "<X> x <Y>" format, where <X> and <Y> are the X-axis and Y-axis pixels
- **Title** – Graphs can have an automatically-generated title for the "Auto" option or title for the "None" option, or you can enter your own text to be rendered as a title
- **Legend** – Select the level of detail for the graph legend
- **Consolidation** – If you are interested in spikes, choose the *MAXIMUM* aggregation type. If you are interested in average values, choose the *AVERAGE* aggregation type. If you are interested in low values, choose the *MINIMUM* aggregation type
- **Grouping**
  - **Servers** – Generate a single graph for the selected servers
  - **Server Interfaces** – Generate a single graph for the network interfaces of the selected servers
- **Stacking**
  - **Servers** – Shows the summed up, stacked values for the selected servers

Console Events

This sub-tab is visible only when opening the Console tab. It lists events generated by Console. Events are described in the "Event Reporting" chapter on page 69.

Server Events

Lists events generated by the selected server(s). The events are described in the "Event Reporting" chapter on page 69.

Server Commands

Console administrators can execute shell commands on the selected server(s) and see the output in the browser. The commands are executed by the WANsupervisor service with the "andrisoft" user's privileges. To prevent the execution of CLI commands via Console, start the WANsupervisor service with the "-n" option.

Appendix 1 – IPv4 Subnet CIDR Notation

Wanguard uses extensively IP addresses and IP classes with the CIDR notation. To view details about any IPv4 subnet click Help → Subnet Calculator.

CIDR MASK	CLASS	HOSTS NO.	MASK
/32	1/256 C	1	255.255.255.255
/31	1/128 C	2	255.255.255.254
/30	1/64 C	4	255.255.255.252
/29	1/32 C	8	255.255.255.248
/28	1/16 C	16	255.255.255.240
/27	1/8 C	32	255.255.255.224
/26	1/4 C	64	255.255.255.192
/25	1/2 C	128	255.255.255.128
/24	1 C	256	255.255.255.000
/23	2 C	512	255.255.254.000
/22	4 C	1024	255.255.252.000
/21	8 C	2048	255.255.248.000
/20	16 C	4096	255.255.240.000
/19	32 C	8192	255.255.224.000
/18	64 C	16384	255.255.192.000
/17	128 C	32768	255.255.128.000
/16	256 C, 1 B	65536	255.255.000.000
/15	512 C, 2 B	131072	255.254.000.000
/14	1024 C, 4 B	262144	255.252.000.000
/13	2048 C, 8 B	524288	255.248.000.000
/12	4096 C, 16 B	1048576	255.240.000.000
/11	8192 C, 32 B	2097152	255.224.000.000
/10	16384 C, 64 B	4194304	255.192.000.000
/9	32768 C, 128B	8388608	255.128.000.000
/8	65536 C, 256B, 1 A	16777216	255.000.000.000
/7	131072 C, 512B, 2 A	33554432	254.000.000.000
/6	262144 C, 1024 B, 4 A	67108864	252.000.000.000
/5	524288 C, 2048 B, 8 A	134217728	248.000.000.000
/4	1048576 C, 4096 B, 16 A	268435456	240.000.000.000
/3	2097152 C, 8192 B, 32 A	536870912	224.000.000.000
/2	4194304 C, 16384 B, 64 A	1073741824	192.000.000.000
/1	8388608 C, 32768 B, 128 A	2147483648	128.000.000.000
/0	16777216 C, 65536 B, 256 A	4294967296	000.000.000.000

Appendix 2 – Configuring NetFlow Data Export

This appendix is a brief guide to setting up the NetFlow data export (NDE) on Cisco and Juniper routers or intelligent Cisco Layer 2/Layer 3/Layer 4 switches. If you have problems with the configuration, contact your network administrator or consultant. For devices that run hybrid mode on a Supervisor Engine (Catalyst 65xx series), it is recommended to configure IOS NDE on the MSFC card and CatOS NDE on the Supervisor Engine. For more information about setting up NetFlow on Cisco, please visit http://www.cisco.com/go/netflow.

Configuring NDE on older IOS Devices

In the configuration mode on the router or MSFC, issue the following to start NetFlow Export.

First, enable Cisco Express Forwarding:

```
router(config)# ip cef
router(config)# ip cef distributed
```

Turn on flow accounting for each input interface with the interface command:

```
interface
ip route-cache flow
```

For example:

```
interface FastEthernet0
ip route-cache flow
interface Serial2/1
ip route-cache flow
```

It is necessary to enable NetFlow on all interfaces through which traffic (you are interested in) will flow. Now, verify that the router (or switch) is generating flow stats – try command 'show ip cache flow'. Note that for routers with distributed switching (GSR's, 75XX's) the RP cli will only show flows that made it up to the RP. To see flows on the individual line cards use the 'attach' or 'if-con' command and issue the 'sh ip ca fl' on each LC.

Enable the exports of these flows with the global commands:

```
router(config)# ip flow-export version 5
router(config)# ip flow-export destination <ip_address> 2000
router(config)# ip flow-export source FastEthernet0
```

Use the IP address of the server running the Flow Sensor and the configured listening port. UDP port 2000 is used as an example. The ‘ip flow-export source’ command is used to set up the source IP address of the exports sent by the equipment.

If your router uses the BGP protocol, you can configure AS to be included in exports with command:

```
router(config)# ip flow-export version 5 [peer-as | origin-as]
```

The following commands break up flows into shorter segments: 1 minute for active traffic and 30 seconds for inactive traffic. Flow Sensor drops flows older than 5 minutes!

```
router(config)# ip flow-cache timeout active 1
router(config)# ip flow-cache timeout inactive 30
```

In enable mode you can see current NetFlow configuration and state.

```
router# show ip flow export
router# show ip cache flow
router# show ip cache verbose flow
```

Configuring NDE on a CatOS Device

In privileged mode on the Supervisor Engine enable NDE:

```
switch> (enable) set mls nde <ip_address> 2000
```

Use the IP address of the server running the Flow Sensor and the configured listening port. UDP port 2000 is used only as an example.

```
switch> (enable) set mls nde version 5
```

The following command is required to set up flow mask to full flows.

```
switch> (enable) set mls flow full
```

The following commands break up flows into shorter segments: ~1 minute for active flows and ~ 30 seconds for inactive flows. Flow Sensor drops flows older than 5 minutes!

```
switch> (enable) set mls agingtime long 8
switch> (enable) set mls agingtime 4
```

If you want to account all traffic within the specified VLANs rather than inter VLAN traffic use CatOS 7.2 or higher and issue the following command:

```
switch> (enable) set mls bridged-flow-statistics enable
```

Enable NDE:

```
switch> (enable) set mls nde enable
```

To see current NetFlow configuration and state issue the following commands:

```
switch> (enable) show mls nde
switch> (enable) show mls debug
```

Configuring NDE on a Native IOS Device

To configure NDE use the same commands as for the IOS device. In the enable mode on the Supervisor Engine, issue the following to set up the NetFlow export version 5.

```
switch(config)# mls nde sender version 5
```

The following commands break up flows into shorter segments: ~1 minute for active flows and ~ 30 seconds for inactive flows. Flow Sensor drops flows older than 5 minutes!

```
switch(config)# mls aging long 8
switch(config)# mls aging normal 4
```

On the Supervisor Engine 1 issue the following to put full flows into the NetFlow exports:

```
switch(config)# mls flow ip full
```

If you have a Supervisor Engine 2 or 720 running IOS version 12.1.13(E) or higher, issue the following commands instead:

```
switch(config)# mls flow ip interface-full
switch(config)# mls nde interface
```

Configuring NDE on a 4000 Series Switch

Configure the switch the same as an IOS device, but instead of command ‘ip route cache flow’ use command ‘ip route-cache flow infer-fields’. This series requires a Supervisor IV with a NetFlow Services daughter card to support NDE.

Configuring NDE on IOS XE

Traditional NetFlow is being replaced with flexible NetFlow on newer IOS versions.

```
conf t
flow exporter WGFlowSensor
destination <ip_address>
source gi0/0/1
transport udp 9991
export-protocol netflow-v5
flow monitor WGFlowSensor
record netflow ipv4 original-input
exporter WGFlowSensor
cache timeout active 120 #in seconds
exit
int gi0/0/2
ip flow monitor WGFlowSensor input
exit
exit
wr mem
```

Configuring NDE on IOS XR

A sample configuration for IOS XR:

```
flow exporter-map wanguard
 version v9
  options interface-table timeout 300
  options vrf-table timeout 300
  options sampler-table timeout 300
 !
 transport udp <port>
 source Loopback8648
 destination <ip_address>
!
flow monitor-map IPV4-FMM
 record ipv4
 exporter wanguard
 cache entries 16384
 cache timeout active 60
 cache timeout inactive 30
!
flow monitor-map IPV6-FMM
 record ipv6
 exporter wanguard
 cache entries 16384
 cache timeout active 60
 cache timeout inactive 30
!
sampler-map 1-of-128
 random 1 out-of 128
!

interface TenGigE0/0/2/1
 description Upstream Interface
 ...
 flow ipv4 monitor IPV4-FMM sampler 1-of-128 ingress
 flow ipv4 monitor IPV4-FMM sampler 1-of-128 egress
 flow ipv6 monitor IPV6-FMM sampler 1-of-128 ingress
 flow ipv6 monitor IPV6-FMM sampler 1-of-128 egress
!
```

Configuring NDE on IOS-XE Everest

```
flow record v4r2
match ipv4 tos
match ipv4 protocol
match ipv4 source address
match ipv4 destination address
match transport source-port
match transport destination-port
match interface input
match flow sampler
collect routing next-hop address ipv4
collect ipv4 source mask
collect ipv4 destination mask
collect transport tcp flags
collect interface output
collect counter bytes
collect counter packets
collect timestamp sys-uptime first
collect timestamp sys-uptime last
collect routing source as 4-octet
collect routing destination as 4-octet
!

flow exporter exporter1
description "exported to external"
destination x.x.x.x
source Loopback0
transport udp 2000
```

```
flow monitor v4r2
exporter external1
cache timeout active 120
record v4r2

sampler external1
mode random 1 out-of 1000

interface GigabitEthernet0/0/0
ip flow monitor v4r2 sampler external1 input
```

Configuring NDE on a Juniper Router (non-MX)

Juniper supports flow exports by the routing engine sampling packet headers and aggregating them into flows. Packet sampling is done by defining a firewall filter to accept and sample all traffic, applying that rule to the interface and then configuring the sampling forwarding option.

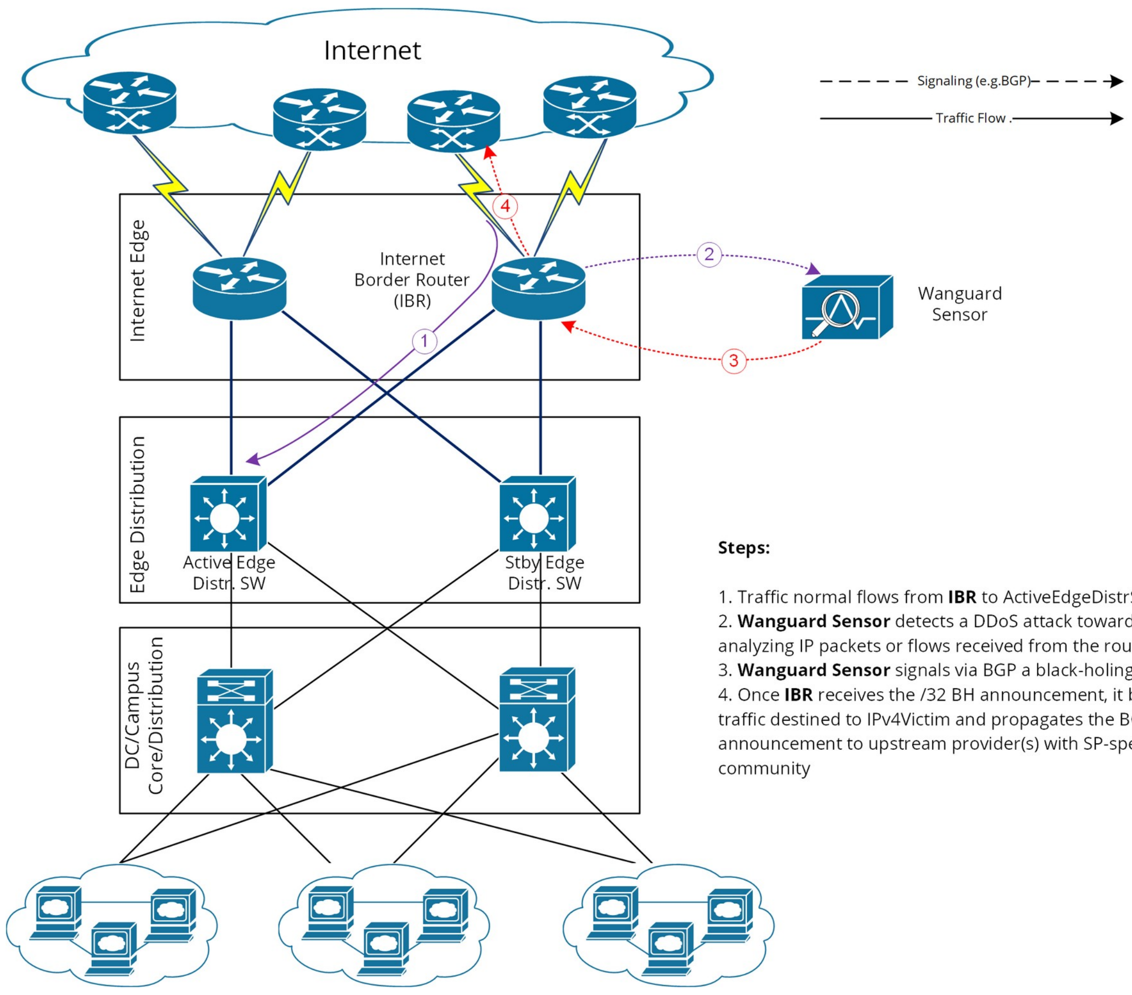
```
interfaces {
       ge-0/1/0 {
              unit 0 {
                     family inet {
                            filter {
                                   input all;
                                   output all;
                            }
                            address 192.168.1.1/24;
                     }
              }
       }
}
firewall {
       filter all {
              term all {
                     then {
                            sample;
                            accept;
                     }
              }
       }
}

forwarding-options {
       sampling {
              input {
                     family inet {
                            rate 100;
                     }
              }
              output {
                     cflowd 192.168.1.100 {
                            port 2000;
                            version 5;
                     }
              }
       }
}
```

Appendix 3 – BGP Black Hole Guideline for Wanguard Sensor

Understanding of RTBH using Wanguard

To simplify, we will start from the following scenario: an attack is detected by Wanguard Sensor (hereby referred simply as **Sensor**) that decides to react by using the BGP black hole approach rather than diverting traffic for scrubbing by Wanguard Filter.



Steps:

1. Traffic normal flows from **IBR** to ActiveEdgeDistrSW
2. **Wanguard Sensor** detects a DDoS attack towards IPv4Victim by analyzing IP packets or flows received from the router
3. **Wanguard Sensor** signals via BGP a black-holing for IPv4Victim
4. Once **IBR** receives the /32 BH announcement, it black-holes traffic destined to IPv4Victim and propagates the BGP /32 announcement to upstream provider(s) with SP-specific BH-community

In RTBH setup, **Sensor** would play the role of **Trigger**. After an attack is detected, **Sensor** signals the **IBR** (Internet Border Router) via BGP that all traffic destined to **IPv4-Victim** has to be dropped. In more details:

- **Sensor** advertises via BGP an **IPv4-Victim**/32 prefix with a specific community to be identified as a Black Hole announcement
- The IBR receives the announcement and it inserts the route in its routing table as **IPv4-Victim**/32 with next-hop Null0.

- Furthermore, the **IBR** advertises this route to its upstream providers (**ISP**s) changing at the same time the community used for internal purposes, to a community which is relevant to the correspondent ISP.

Black-holing on upstream

The principle of DDoS mitigation using black hole BGP advertisements is to propagate the BH-prefix from the destination of the attack closest as possible to the source. Most ISPs have defined a public community, based on which their IBRs take the decision to black hole the traffic destined to the victim by routing it to Null0. In comparison to redirect announcements, the black-holing announcements have to be advertised to upstream ISPs.

In order to black hole the attack on the upstream provider, the black hole route must be tagged/marked with an appropriate BGP standard community. This community is provider-specific and has to be requested by each customer to the provider, or it might be found on IRR ASN details (e.g. RIPE, APNIC, ARIN, etc.).

On IBR there shall be a routing-policy applied to the to-ISP-BGP neighbor (export-direction) which shall **rewrite** the internal BH-community to appropriate ISP's BH-community.

From a BGP configuration point of view, the Sensor's configuration is quite similar to Filter's BGP configuration explained in Annex 4 on page 116, having one exception in regards to the BGP community that will be used to mark black hole routes. Considering this, only the IBR's configuration will be further detailed.

IBR BGP Session with Wanguard Sensor – Cisco Router BGP Configuration

```
r7500(config)# ip bgp-community new-format
r7500(config)# ip community-list <Wanguard-Sensor-community-name> permit <BH-community> →
e.g. 65000:66
r7500(config)# route-map Wanguard-Filter-in permit 10
r7500(config-route-map)# match community <Wanguard-Sensor-community-name>
r7500(config-route-map)# set local-preference 200 → it will assure a higher priority against
redirect-route
r7500(config-route-map)# set ip next-hop 192.168.255.255 → this target-IP must not be used
on your network
r7500(config-route-map)# exit
r7500(config)# route-map Wanguard-Sensor-out deny 10
r7500(config-route-map)# exit
r7500(config)# ip route 192.168.255.255 255.255.255.255 Null0 → BH route for target-IP
r7500(config)# router bgp <Router-AS-number>
r7500(config-router)# bgp log-neighbor-changes
r7500(config-router)# neighbor <Wanguard-Sensor-IP-address> remote-as <Wanguard-Sensor-AS-
number>
r7500(config-router)# neighbor <Wanguard-Sensor-IP-address> description <description>
r7500(config-router)# neighbor <Wanguard-Sensor-IP-address> soft-reconfiguration-inbound
r7500(config-router)# neighbor <Wanguard-Sensor-IP-address> route-map Wanguard-Sensor-out
out
r7500(config-router)# neighbor <Wanguard-Sensor-IP-address> route-map Wanguard-Sensor-in in
r7500(config-router)# no synchronization
r7500(config-router)# exit
```

BGP Session with Two ISPs – Cisco Router BGP Configuration

```
r7500(config)# route-map IBR-ISP1-out permit 5 → assumes that additional entries are defined
and allow customer-routes
```

```
r7500(config-route-map)# match community <Wanguard-Sensor-community-name>
r7500(config-route-map)# set community <ISP1-BH-Community> → e.g.111:9999
r7500(config-route-map)# exit
r7500(config)# route-map IBR-ISP2-out permit 5 → assumes that additional entries are defined
and allow customer-routes
r7500(config-route-map)# match community <Wanguard-Sensor-community-name>
r7500(config-route-map)# set community <ISP1-BH-Community> → e.g.222:9999
r7500(config-route-map)# exit
r7500(config)# router bgp <Router-AS-number>
r7500(config-router)# neighbor <IPS1-IP-address> remote-as <ISP1-AS-number>
r7500(config-router)# neighbor <IPS1-IP-address> route-map IBR-ISP1-out out
r7500(config-router)# neighbor <IPS2-IP-address> remote-as <ISP2-AS-number>
r7500(config-router)# neighbor <IPS2-IP-address> route-map IBR-ISP2-out out
r7500(config-router)# no synchronization
r7500(config-router)# exit
```

When multiple ISPs and IBRs exist, it makes sense to have different BH communities, one for each IBR. In this way you may isolate the source of the attack so that the whole traffic directed to the victim would not be black-holed.

Interaction with traffic diversion / Wanguard Filter

It might be the case when:

- Filter advertises redirect BGP route to IBR (initially)
- Sensor advertises a black-hole BGP route to IBR (afterward)

The priority shall be on the black-hole advertisement, rather than redirect. This can be achieved easily by using a routing-policy which sets a higher priority on black hole route (e.g. set Local-Preference at 200 for BH-route).

The direction and place where BGP routing-policy has to be implemented are strongly dependent on:

- What role plays on the network the Sensor's peer-router (e.g. IBR, Route-Reflector, etc.)
- Type of BGP relation between Sensor and the peer-router (e.g. iBGP or eBGP)

In order to distinguish between a black hole and a redirect announcement, it is recommended to use different BGP communities on each type of announcement.

The action shall be like on the table below:

Type of BGP announcement (community)	Route to (next-hop)	Propagated to ISP
Redirect (e.g. 65000:99)	Wanguard Filter	No
Black-hole (e.g. 65000:66)	Null0	Yes

Table 1 – BGP Communities and actions

In the special case when the peer-router of Sensor is the Route-Reflector, then the black-hole action still has to be implemented on IBR. To achieve this, the above sample router configuration has to be adapted and applied to IBR BGP-import policy in relation to the Route-Reflector. No action has to be implemented on RR, while its purpose is route-signaling rather than routing traffic.

To use a single bgpd / peer router for both redirect and black-hole, define *bgp multiple-instance* in bgpd.conf and use two BGP Connectors configured with distinct AS views. For the second AS view assign a different IP for *bgp router-id* and make sure the IP (sub-interface) can reach the router.

Appendix 4 – Network Integration Guideline for Wanguard Filter

This appendix describes how to configure the network for traffic scrubbing by **Wanguard Filter,** starting from a couple of common deployment scenarios of the filtering server.

Wanguard Filter, hereby referred simply as **Filter**, can be deployed following two scenarios:

- **In-line filtering**. This deployment scenario can have two possible implementations, depending on the role of the filtering server on the forwarding path:
  - *Routing mode*
  - *Bridging mode*
- **Out-of-line filtering**. Due to the complexity of this solution, this appendix will further focus on this setup.

When the **Out-of-line filtering** solution is deployed, then the following two major operations have to be considered, operations that have to be performed from network point of view:

1. **Traffic diversion** – how the traffic for a certain destination (**IP-Victim**) is diverted from network to the filtering server
2. **Traffic forwarding** or **Re-injection** – how the cleaned traffic is put back on network to be routed / forwarded towards its destination (**IP-Victim**)

The information provided here regarding router configurations is for informational purposes only. Please refer to the appropriate router user guides for more detailed and up-to-date information.

Understanding the Traffic Diversion Method

The method relies on a basic routing principle implemented on all routers according to which a router selects the path with the longest prefix match present on routing table (also known as the “most specific” entry from routing table).

BGP has been chosen as routing protocol to inject/advertise the most specific redirect-prefix (e.g. a /32 for IPv4, a /128 for IPv6) towards *Internet Border Router (IBR).* The IBR is the router which assures routing between ISP and the internal network (customer network).

To simplify, we will consider an **IPv4-Victim**. In this case, **Filter** sends a BGP routing update towards IBR for **IPv4-Victim**/32 with a next-hop to itself forcing the IBR to choose the path to **IPv4-Victim** via **Filter**. The main condition for this to work is to have the redirect announcement to be the best from BGP election process and from *Routing-Table Manager (RTM).*

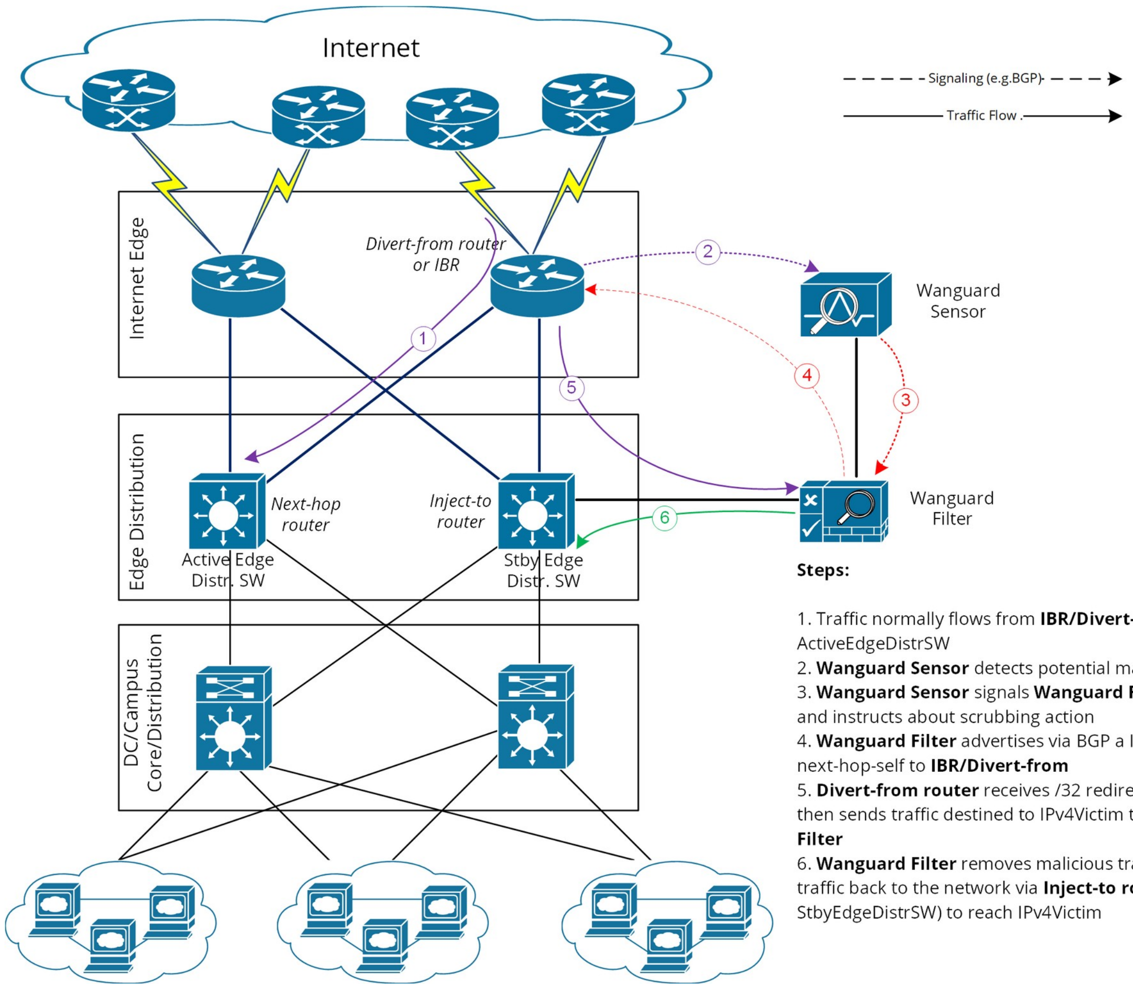
If on the routing-table there is already a /32 present, then additional configuration have to be made in order to assure that redirect-announcement will be inserted into the routing table and used to deciding the forwarding path.

Please refer to the following logical diagram that describes the high-level process of detection-diversion-cleaning and re-injection.

The following terminology is used:

- **Divert-from router** – Router from which traffic, initially intended for the victim, is diverted towards **Filter** (e.g. *IBR*) – this router has to receive a redirect-prefix via BGP

- **Inject-to router** – Router where **Filter** will forward the cleaned traffic towards the attacked destinations (IP-Victims)
- **Next-hop router** – Router that is usually the next-hop to the destinations according to the routing-table on the **Divert-from router** before traffic diversion is activated.



Steps:

1. Traffic normally flows from **IBR/Divert-from** to ActiveEdgeDistrSW
2. **Wanguard Sensor** detects potential malicious traffic
3. **Wanguard Sensor** signals **Wanguard Filter** about IPv4Victim and instructs about scrubbing action
4. **Wanguard Filter** advertises via BGP a IPv4Victim route with next-hop-self to **IBR/Divert-from**
5. **Divert-from router** receives /32 redirect BGP announcement, then sends traffic destined to IPv4Victim towards **Wanguard Filter**
6. **Wanguard Filter** removes malicious traffic and sends clean traffic back to the network via **Inject-to router** (in this case StbyEdgeDistrSW) to reach IPv4Victim

Figure-1. Logical Diagram for an Enterprise Network – how traffic diversion works

From a configuration point of view the following steps have to be performed:

1. Configure *traffic-diversion* using BGP as the signaling method
2. Configure an appropriate clean *traffic-injection* method to send clean traffic back on the network to be forwarded towards the victim

BGP Configuration Guideline

This section provides a general guideline for BGP configuration on the **Filter** server and on a *Divert-from router*. The guidelines provided in this section apply to the BGP configuration on any router from which **Filter** diverts traffic.

To simplify, the following examples are provided using eBGP (external BGPv4). This solution is not limited to eBGP, iBGP may be considered as well, depending on existing network setup, case in which "*set nexthop-self*" feature might be required.

The steps below have to be followed:

1. Configure BGPd on ***Filter*** with an easily recognizable autonomous system number. This can be a private ASN for eBGP (e.g. ASN16bit 64512-65534) or your own public ASN in case you are using iBGP. The BGPd sends routing information only when it diverts traffic. This route appears in the router's routing tables. Using a recognizable value allows you to easily identify the *redirect-prefixes* in the router's routing tables.
2. Configure additional precaution measures to prevent any undesirable routing behavior:
   a. Configure ***Filter*** to not accept any prefix/advertisements from ***Divert-from*** *router*
   b. Configure ***Divert-from*** *router* to not advertise any prefix towards ***Filter***
   c. Configure ***Divert-from*** *router* to accept only redirect-prefixes from ***Filter*** (e.g. /32 prefixes)
   d. Configure ***Filter*** to advertise the redirect-prefixes with well-known community *no-advertise* – this would prevent redirect-prefixes/announcements to be propagated to other peers through BGP. The *no-export* community might be used in case redirect-prefix has to be advertised to additional routers, or Route-Reflectors are used in-between ***Filter*** and ***Divert-from*** router. Both communities will prevent BGP-redirect-announcements to be advertised towards upstream providers. However, a good practice is to mark this announcement with a dedicated BGP community to distinguish between redirect and black hole announcements.

3. To ease the troubleshooting process, you may consider the *soft-reconfiguration inbound* command on ***Divert-from-router*** during the setup procedures.

Quagga / FRR bgpd Configuration

Wanguard is capable of sending and withdrawing BGP announcements via the BGPd daemon provided by the Quagga routing software suite (https://www.quagga.net). Newer Linux distributions, like CentOS 8, don't support Quagga, but support FRR (https://frrouting.org). FRR is a fork of Quagga, so the configuration differences are minimal.

After installing Quagga, you will have to do a few distribution-specific configuration changes:

■ On Red Hat or CentOS systems, edit /etc/sysconfig/quagga and replace *BGPD_OPTS="-A 127.0.0.1"* with *BGPD_OPTS=""*.

```
[root@localhost ~]# nano /etc/sysconfig/quagga → on CentOS 6 or 7 systems
```

■ On Debian or Ubuntu systems, edit /etc/quagga/daemons and replace *bgpd=no* with *bgpd=yes*. Then, edit /etc/quagga/debian.conf and replace *bgpd_options=" --daemon -A 127.0.0.1"* with *bgpd_options=" --daemon"*.

```
[root@localhost ~]# nano /etc/quagga/daemons → on Debian or Ubuntu systems
[root@localhost ~]# nano /etc/quagga/debian.conf → on Debian or Ubuntu systems
```

Wanguard needs to connect to bgpd on the public IP of the server, even if the connection will be made from the server itself via the WANsupervisor service. This is why the string "-A 127.0.0.1", which is used for binding bgpd to the loopback interface, must be deleted.

To be able to start the bgpd service, create a basic configuration file. Setting a password for the bgpd daemon is usually enough to get it started. You should replace “bgppass” with your own password.

```
[root@localhost ~]# echo 'password bgppass' > /etc/quagga/bgpd.conf
[root@localhost ~]# chown quagga /etc/quagga/bgpd.conf
[root@localhost ~]# service bgpd start → on Red Hat or CentOS systems
[root@localhost ~]# service quagga start → on Debian or Ubuntu systems
```

It is always a good idea to tighten the security of the bgpd daemon. Connect to the bgp daemon with telnet on localhost port 2605 (default bgpd port) with the previously-defined password (“bgppass”). Execute the following commands and replace “enablepass” with your own configuration-mode password.

```
[root@localhost ~]# telnet 127.0.0.1 2605
localhost> enable
localhost# config terminal
localhost(config)# service password-encryption
localhost(config)# enable password enablepass
localhost(config)# write
```

Configure routing on BGPd using the commands shown in the following example. Please note that you can use the prefix-list, route-map, or distribute-list method for filtering outgoing routing information. To have a uniform approach, the following example uses route-maps. Optionally, BGP authentication can be configured to increase security and avoid any illegal BGP announcement which may lead to a security breach.

```
localhost(config)# router bgp <Wanguard-Filter-AS-number>
localhost(config-router)# bgp router-id <Wanguard-Filter-IP-address>
localhost(config-router)# neighbor <Router-IP-address> remote-as <Router-AS-number>
localhost(config-router)# neighbor <Router-IP-address> description <description>
localhost(config-router)# neighbor <Router-IP-address> password <BGP MD5 password>
localhost(config-router)# neighbor <Router-IP-address> route-map Wanguard-Filter-in in
localhost(config-router)# neighbor <Router-IP-address> route-map Wanguard-Filter-out out
localhost(config-router)# exit
localhost(config)# route-map Wanguard-Filter-in deny 10
localhost(config-route-map)# exit
localhost(config)# route-map Wanguard-Filter-out permit 10
localhost(config-route-map)# set community no-advertise <Wanguard-Filter-community>
localhost(config-route-map)# exit
localhost(config)# write
localhost(config)# exit
```

To display the bgpd configuration, enter the *show running-config* command from the “enable” command level. In the following example, the router's AS number is 1000, and the BGPd AS number is 65000.

The following partial sample output is displayed:

```
localhost# show running-config
... skipped ...
router bgp 65000
bgp router-id 192.168.1.100
neighbor 192.168.1.1 remote-as 1000
neighbor 192.168.1.1 description divert-from router
neighbor 192.168.1.1 soft-reconfiguration inbound
neighbor 192.168.1.1 route-map Wanguard-Filter-in in
neighbor 192.168.1.1 route-map Wanguard-Filter-out out
!
route-map Wanguard-Filter-in deny 10
!
route-map Wanguard-Filter-out permit 10
set community no-advertise
!
line vty
... skipped ...
```

Wanguard connects to bgpd using the BGP Connector component documented on page 55. Make sure that the wanbgp package is installed on the bgpd server.

ExaBGP Configuration

Use ExaBGP 4.0 instead of Quagga and FRR if you want to use Flowspec.

On Debian / Ubuntu systems, install ExaBGP 4.0 from git, and then install socat by executing:

```
[root@localhost ~]# apt-get install socat
```

On RedHat / CentOS systems, install ExaBGP 4.0 from git, and then install socat by executing:

```
[root@localhost ~]# yum install socat
```

The bolded lines from the configuration file listed below are mandatory. The rest of the lines are given as an example.

```
process announce-routes {
    run /usr/bin/socat stdout pipe:/var/run/exabgp.cmd;
    encoder json;
}

neighbor 192.168.50.1 {
    # ID for this ExaBGP router
    router-id 192.168.50.2;
    local-address 192.168.50.2;
    # local AS number
    local-as 65001;
    # remote AS number
    peer-as 12345;
    group-updates false;

    family {
        ipv4 flow;
    }
    api {
        processes [ announce-routes ];
    }
}
```

Start ExaBGP with a command such as:

```
env exabgp.daemon.user=root exabgp.daemon.daemonize=true
exabgp.daemon.pid=/var/run/exabgp.pid
exabgp.log.destination=/var/log/exabgp.log /opt/exabgp4/sbin/exabgp
/etc/exabgp/exabgp_example.conf
```

Verify that ExaBGP starts and functions correctly by inspecting /var/log/exabgp.log.

Wanguard connects to ExaBGP using the BGP Connector component documented on page 55. Make sure that the wanbgp package is installed on the exabgp server.

Cisco Router BGP Configuration

This section describes the router's BGP configuration used when configuring traffic diversion. The syntax of the commands is taken from the BGP configuration of a Cisco router. The following configuration steps show the commands used to configure BGP on a 72xx Cisco router:

```
r7200(config)# ip bgp-community new-format
r7200(config)# ip community-list standard <Wanguard-Filter-community-name> permit no-
advertise
r7200(config)# ip community-list standard <Wanguard-Filter-community-name> permit <Wanguard-
Filter-community>
r7200(config)# route-map Wanguard-Filter-in permit 10
r7200(config-route-map)# match community <Wanguard-Filter-community-name> exact
r7200(config-route-map)# exit
r7200(config)# route-map Wanguard-Filter-out deny 10
r7200(config-route-map)# exit
r7200(config)# router bgp <Router-AS-number>
r7200(config-router)# bgp log-neighbor-changes
r7200(config-router)# neighbor <Wanguard-Filter-IP-address> remote-as <Wanguard-Filter-ASn>
r7200(config-router)# neighbor <Wanguard-Filter-IP-address> description <description>
r7200(config-router)# neighbor <Wanguard-Filter-IP-address> soft-reconfiguration-inbound
r7200(config-router)# neighbor <Wanguard-Filter-IP-address> route-map Wanguard-Filter-out
out
r7200(config-router)# neighbor <Wanguard-Filter-IP-address> route-map Wanguard-Filter-in in
r7200(config-router)# exit
```

To display the router configuration, enter the *show running-config* command from the router global command level. In the following example, the router's AS number is 1000 and the BGPd AS number is 64000. The following partial output is displayed:

```
r7200# show running-config
... skipped ...
router bgp 1000
bgp log-neighbor-changes
neighbor 192.168.1.100 remote-as 64000
neighbor 192.168.1.100 description Filter appliance
neighbor 192.168.1.100 soft-reconfiguration inbound
neighbor 192.168.1.100 route-map Wanguard-Filter-out out
neighbor 192.168.1.100 route-map Wanguard-Filter-in in
no synchronization
!
```

```
ip bgp community new-format
ip community-list expanded Wanguard-Filter permit no-advertise
ip community-list expanded Wanguard-Filter permit <Wanguard-Filter-community>
!
route-map Wanguard-Filter-in permit 10
  match community Wanguard-Filter exact match
!
route-map Wanguard-Filter-out deny 10
!
... skipped ...
```

Understanding the Traffic Forwarding Methods

This section provides some details about the traffic forwarding methods typically used with Wanguard. A traffic forwarding method must be used to re-inject cleaned traffic from the **Filter** server back to network in order to reach its destination.

Couple of options can be identified depending on the existing network setup and depending on which device has the role of **Divert-from**, **Inject-to**, and **Next-hop** router:

1. **Layer 2 Forwarding Method**
2. **Layer 3 Forwarding Method**

Layer 2 Forwarding Method

The following characteristics will describe this option:

- **Filter** system, **Divert-from** router, and **Next-hop** router are on the same network or VLAN sharing the same subnet
- **Divert-from** and **Inject-to** routers are two different devices
- **Next-hop** and **Inject-to** routers are the same device

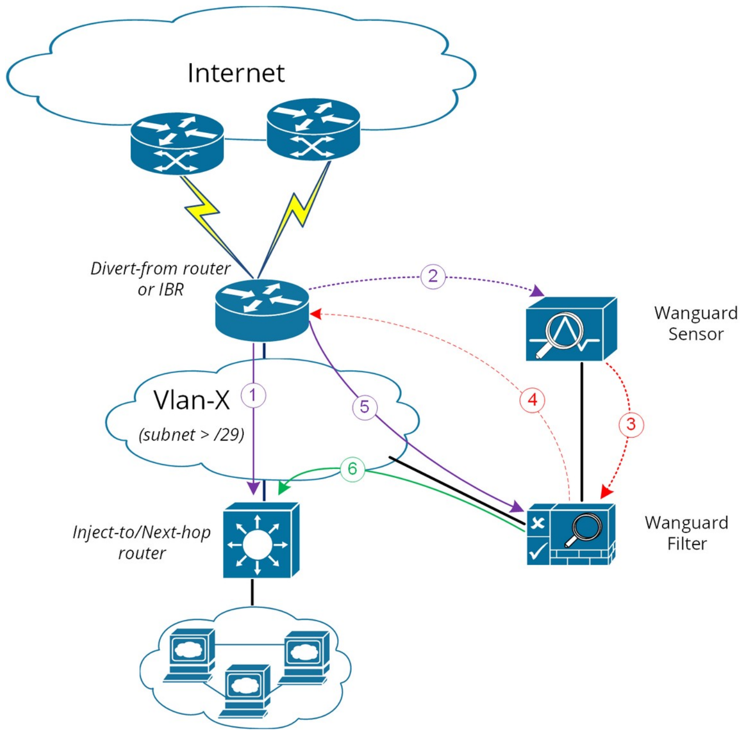


Figure-2. Logical Diagram for Layer 2 Forwarding (**same steps as per Fig.1*)

While the above solution assumes one **Divert-from** and one **Inject-to** router, couple of variations may be considered starting from this option:

a) Multiple **Divert-from** routers

b) Multiple **Inject-to** routers

c) Combination of above and/or multiple VLANs in between **Divert-from** and **Inject-to** routers

Considering the last scenario, the **Filter** system has to be connected to each VLAN and to have static routes for each destination via the **Inject-to**/**Next-hop** routers.

Warning: *Any special L2 configuration on Filter interface (e.g. bonding, VLAN-tagging, etc) will impact the scrubbing/forwarding performance of Filter. Hardware optimizations from NICs are also bypassed.*

When the VLAN/LAN cannot be extended to also include the **Filter** system on it, then a dedicated point-to-point connection might be considered between (**Filter** and **Divert-from**) or (**Filter** and **Inject-to/Next-hop**)

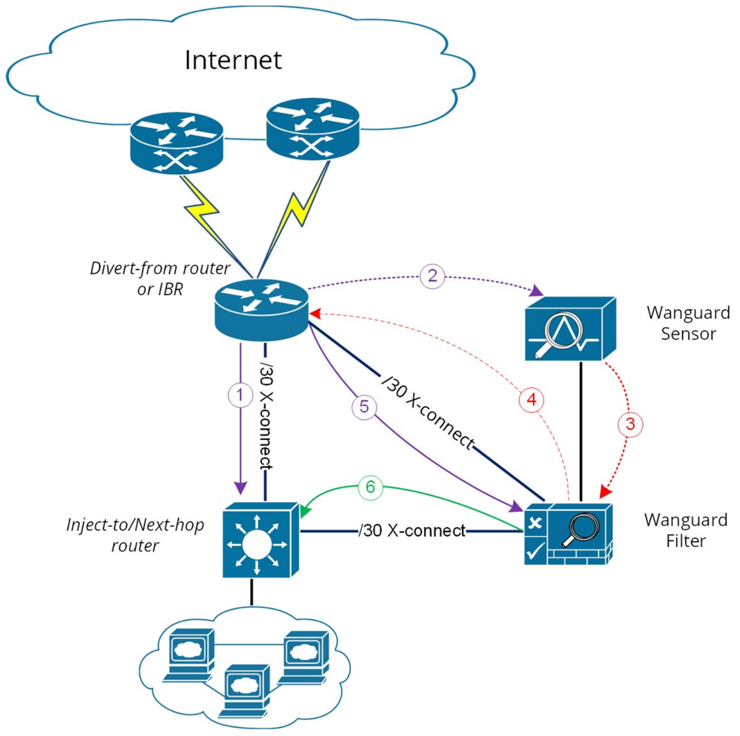


Figure-3. Logical Diagram Layer 2 Forwarding – dedicated cross-connects (***same steps as per Fig.1*)

Layer 3 Forwarding Method

The following characteristics will describe this option:

1. **Divert-from** and **Inject-to** routers are the same device – referred in this case as "the router"
2. Depending on **Next-hop** router role we may have following sub-options:
   a) **Next-hop** router is on dedicated device, but is not directly connected to **Filter**
   b) **Next-hop** router is on the same device as **Diver-from/Inject-to** routers

In scenario 2a, a routing loop issue may occur between **Divert-from/Inject-to** router and **Filter**:

- **Filter** sends a BGP redirect announcement to **Divert-from** router (e.g. a /32 prefix route)

- **Divert-from** router will send all traffic for that **Victim-IP** to **Filter**
- **Filter** cleans the traffic and returns the cleaned traffic to the same router – Inject-to/Divert-from
- The **Inject-to** router has the redirect route /32 in its routing table and will send back the clean-traffic towards the **Filter** system resulting a routing loop

There are a couple of solutions to overcome this issue (these are suggestions and the best solution shall not be limited on these):

1. Using **GRE** (Generic Routing Encapsulation) or any L3-tunneling between **Filter** and **Next-hop** router – in this case, routing loop is avoided by pushing clean traffic over the GRE-tunnel to **Next-hop** router through **Divert-from/Inject-to** router, bypassing in this way the /32 diversion-route from **Divert-from/Inject-to**:

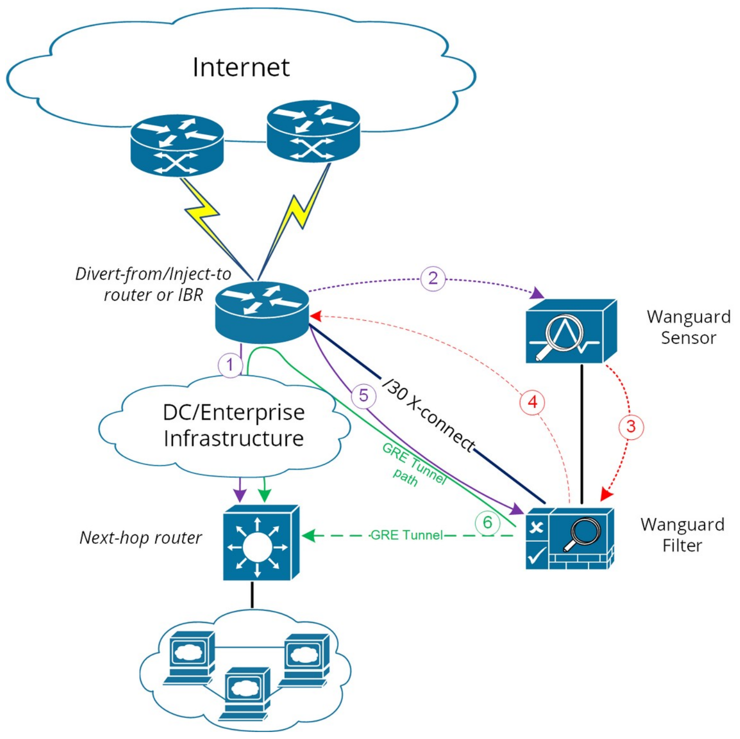


Figure-4. Logical Diagram Layer 3 Forwarding using GRE (******same steps as per Fig.1*)

2. Using **PBR** (Policy Base Routing) to override the normal routing decision from **Divert-from/Inject-to** router:

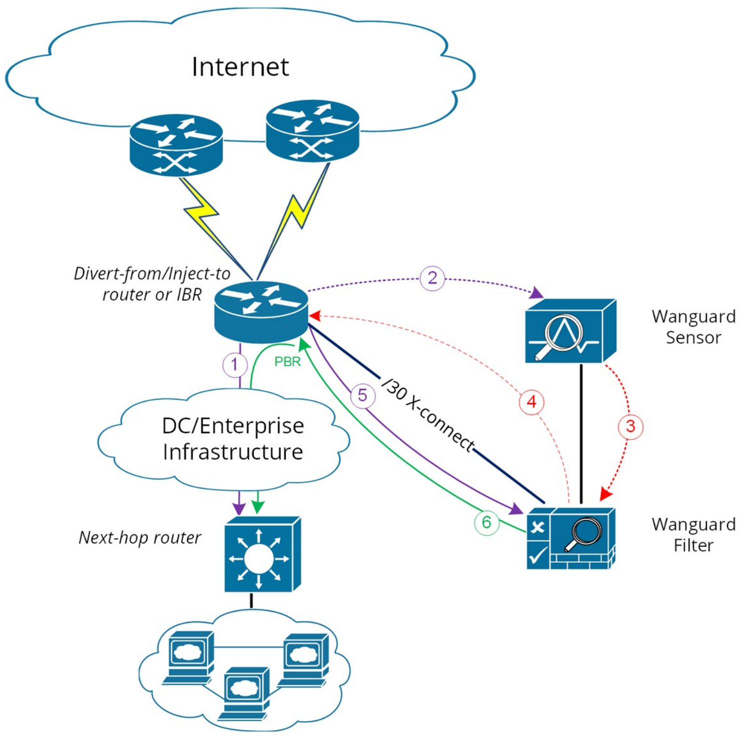


Figure-5. Logical Diagram Layer 3 Forwarding using PBR (**same steps as per Fig.1*)

Warning: PBR may impact router performance – depending on platform type, some optimizations may exist. However, by default PBR relays on packet-by-packet processing (process-switching) which have a significant impact on router's CPU.

In case multiple **Next-hop** routers exist, then the following have to be considered too:

- multiple GRE tunnels have to be deployed and static routes at **Filter** level have to be considered, or
- multiple entries on PBR matching each zone, depending on which option is chosen

When using GRE, you must run on **Filter** the standard Linux tool *ip* in order to create and route GRE / IP over IP tunnels that will be used to inject the cleaned traffic back into the network. You must then configure **Filter** (see Packet Filter Configuration) with the Outbound Interface set to the virtual network interface created by the tunnel.

Please refer to the below router configuration samples for both GRE and PBR options:

1. The GRE method (using Cisco CLI) – configuration from **Next-hop** router:

```
r7200(config)# interface Tunnel 1
r7200(config-if)# ip address <X.X.X.X> 255.255.255.252
r7200(config-if)# ip mtu 1500
r7200(config-if)# ip tcp adjust-mss 1456
r7200(config-if)# tunnel source <Y.Y.Y.Y> → where Y.Y.Y.Y is the IP from Next-hop router
r7200(config-if)# tunnel destination <Z.Z.Z.Z> → where Z.Z.Z.Z is the IP from Filter
```

Notes:

- *source IP and destination IP have to be reachable*
- *default tunneling encapsulation is GRE*

- *routing of tunnel-destination must be assured (e.g. using static routes)*
- ***Filter** will have X.X.X.X-1 IP on its Tunnel interface*
- *If transport between **Filter** and **Next-hop router** supports jumbo frames, then adjust MTUs accordingly in order to avoid additional packet fragmentation, and implicitly performance degradation*

2. The PBR method (using Cisco CLI):

```
r7200(config)#ip access-list standard Wanguard-Filter-IPScope
r7200(config-std-acl)#permit A.A.A.A/BB → multiple entries may exists
r7200(config-std-acl)#exit

r7200(config)#route-map Wanguard-Filter-PBR permit 10
r7200(config-route-map)# match ip address Wanguard-Filter-IPScope
r7200(config-route-map)# set ip next-hop <C.C.C.C> → where C.C.C.C is the IP of Next-hop
router which is direct connected to Divert-from router
r7200(config-route-map)#exit
r7200(config)#interface GigabitEthernet 0/0
r7200(config-if)#ip policy route-map Wanguard-Filter-PBR
r7200(config-if)#exit
r7200(config)#
```

On scenario 2b when only one device has all three roles: **Divert-from**, **Inject-to**, and **Next-hop** – neither of above options can be considered. PBR might be considered in case a "set interface" configuration may take traffic and put it on the right Layer 2 path to its destination; since this is dependent on the type of platform used for routing, this would have limited applicability and will not be treated further more.

For scenario 2b a much more elaborated solution has to be considered. The main idea is to separate virtually the routing domain used by **Divert-from** and **Inject-to**/**Next-hop** router – falling in this way somehow on ***Layer 2 Forwarding Method***:

- use VRF-Lite by defining two VRF's:
  - one for "**outside**" where **Divert-from** router is (and also its BGP peering with upstream providers and **Filter**)
  - and another one for "**inside**" where **Inject-to**/**Next-hop** router is
- **Filter** must have two Layer 3 interfaces/sub-interface:
  - one in **VRF-outside**
  - one in **VRF-inside**
- like on ***Layer 2 Forwarding Method***, static routes have to be defined on **Filter** towards subnets destinations
- in order to assure normal routing between these two VRF's, MPBGP have to be activated on "**the router**"; no MPBGP neighbor have to be defined
- on VRF's definitions special policies for import/export Route-Targets(RT) have to be defined in the following manner:
  - e.g. mark outside routes with RT 65000:100 and inside routes RT 65000:200
  - on **VRF-outside**:
    - import the routes having outside-RT (e.g. 65000:100) and also inside-RT (e.g. 65000:200)
    - export routes with outside-RT – <u>excepting the redirect/diversion routes</u>

- on **VRF-inside:**
  - import the routes having inside-RT and specific routes having outside-RT: the default-route and/or all other outside routes excepting the routes for diversion learned from **Filter**
  - export routes with inside-RT

In this way, the inside routing table will not know about the /32 redirect prefix and will forward/route traffic normally.

For a better understanding please refer to **Figure-6** and configuration on "**router**" using Cisco-CLI as example:

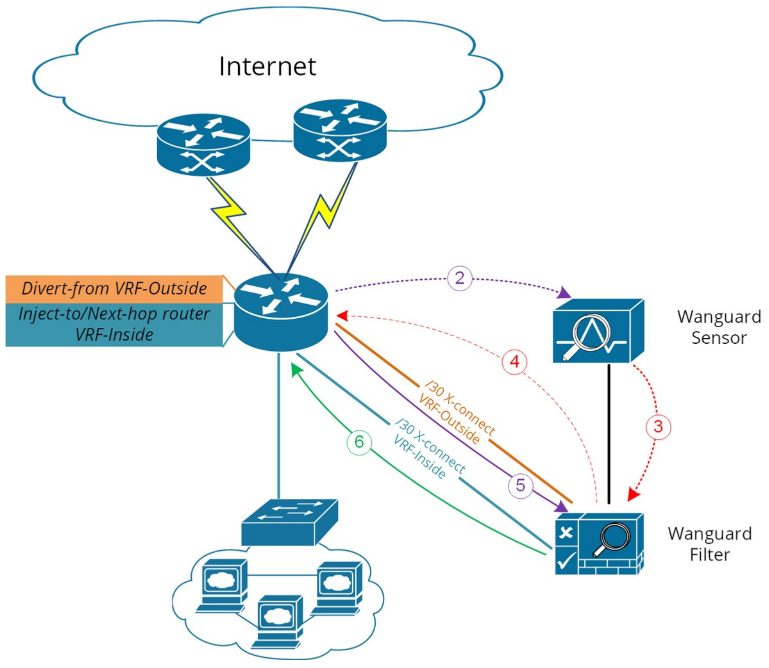


Figure-6. Logical Diagram Layer 3 Forwarding using VRF-Lite (**same steps as per Fig.1*)

```
r7200(config)#ip extcommunity-list standard VRF-Inside permit rt 65000:200
r7200(config)#route-map VRF-Inside-Import deny 10
r7200(config-route-map)#match community Wanguard-Filter → The Wanguard-Filter community has
been already configured above; this will deny redirect-routes
r7200(config-route-map)#exit
r7200(config)#route-map VRF-Inside-Import permit 20 → This will allow any other routes
r7200(config-route-map)#exit
r7200(config)#
r7200(config)#ip vrf Outside
r7200(config-vrf)#rd 65000:100
r7200(config-vrf)#route-target import 65000:100
r7200(config-vrf)#route-target import 65000:200
r7200(config-vrf)#route-target export 65000:100
r7200(config-vrf)#exit
r7200(config)#
r7200(config)#ip vrf Inside
r7200(config-vrf)#rd 65000:200
r7200(config-vrf)#route-target import 65000:100
r7200(config-vrf)#route-target import 65000:200
r7200(config-vrf)#import map VRF-Inside-Import
r7200(config-vrf)#route-target export 65000:200
```

```
r7200(config-vrf)#exit
r7200(config)#
r7200(config)# interface Loopback0 → This is needed to have a BGP router-id (any existing
Loopback from global can be reused)
r7200(config-if)# ip address <Z.Z.Z.Z/32>
r7200(config-if)#no shut
r7200(config-if)#exit
r7200(config)#
r7200(config)# interface <to Upstream Provider>
r7200(config-if)#ip vrf forwarding Outside → Warning! This will remove IP address from
interface/IP-address has to be reconfigured again
r7200(config-if)#exit
r7200(config)#
r7200(config)# interface <to Filter off-ramp interface>
r7200(config-if)#ip vrf forwarding Outside → Warning! This will remove IP address from
interface/IP-address has to be reconfigured again
r7200(config-if)#exit
r7200(config)#
r7200(config)# interface <to Filter on-ramp interface>
r7200(config-if)#ip vrf forwarding Inside → Warning! This will remove IP address from
interface/IP-address has to be reconfigured again
r7200(config-if)#exit
r7200(config)#
r7200(config)# interface <to Inject-to/Next-hop>
r7200(config-if)#ip vrf forwarding Inside → Warning! This will remove IP address from
interface/IP-address has to be reconfigured again
r7200(config-if)#exit
r7200(config)#
r7200(config)#router bgp 65000 → You may use your ASN instead of 65000
r7200(config-router)# no synchronization
r7200(config-router)#bgp log-neighbor-changes
r7200(config-router)#no auto-summary
r7200(config-router)#address-family vpnv4
r7200(config-router-af)# no synchronization
r7200(config-router-af)#exit-address-family
r7200(config-router)# address-family ipv4 vrf Inside
r7200(config-router-af)# no synchronization
r7200(config-router-af)# redistribute connected
r7200(config-router-af)# redistribute <other IGP/static if needed>
r7200(config-router-af)#exit-address-family
r7200(config-router)# address-family ipv4 vrf Outside
r7200(config-router-af)# no synchronization
r7200(config-router-af)# redistribute connected
r7200(config-router-af)# redistribute <other IGP/static if needed>
r7200(config-router-af)#exit-address-family
r7200(config-router)#exit
r7200(config)#
```

If too many GRE tunnels or PBR entries have to be configured/maintained, consider the VRF-Lite solution.

Appendix 5 – Conditional Parameters & Dynamic Parameters

ANOMALY PARAMETERS				
#	CONDITIONAL PARAMETER	TYPE	DYNAMIC PARAMETER	DESCRIPTION
1	IP Address	String	`{ip}`	IP address or block, originating or being the target of the anomaly
2	N/A	String	`{ip_dns}`	Reverse DNS of the anomaly IP. It is {ip} if the DNS lookup does not return a valid DNS PTR record
3	CIDR	Number	`{cidr}`	CIDR mask of the anomaly's IP address or block
4	Prefix	String	`{prefix}`	IP/CIDR mask notation with the anomaly's IP address or block
5	IP Group	String	`{ip_group}`	IP Group defined in IP Zone for the prefix
6	Sensor Name	String	`{sensor}`	Sensor that detected the anomaly
7	Sensor Group	String	`{sensor_group}`	Device Group configured for the Sensor
8	Sensor IP	String	`{sensor_ip}`	IP of the Sensor's server
9	Sensor Type	String	`{sensor_type}`	Can be Packet Sensor, Flow Sensor, SNMP Sensor, Sensor Cluster
10	Sensor ID	Number	`{sensor_id}`	Unique ID of the Sensor
11	Flow Exporter IP	String	`{router_ip}`	IP of the flow exporter
12	IP Zone Name	String	`{ipzone}`	Sensor's IP Zone
13	IP Zone Prefix	String	`{prefix_ipzone}`	The most specific prefix from the IP Zone
14	Response Name	String	`{response}`	Response activated by the anomaly
15	Response Actions	String	`{response_actions}`	List of actions executed by the Response. Contains only the actions that have the Record Action option enabled
16	Template Name	String	`{template}`	Returns the Threshold Template that includes the threshold rule, if it exists
17	Expiration Delay	String	`{expiration}`	Returns the number of seconds of inactivity before the anomaly expires
18	Captured Packets	Number	`{captured_pkts}`	When the Response contains an action for capturing packets, it contains the number of packets captured successfully
19	BGP Log Size	Number	`{bgplog_bytes}`	Size of the BGP announcement log. Non-zero when a BGP routing update was triggered for the anomaly

20	Unique Dynamic Parameters	String	`{exclusive}`	Contains dynamic parameter(s) that must be unique in all active anomalies. It can be used to avoid duplicating actions across multiple attacks. Example: "{ip} {decoder}" executes the Response action only when there is no other active anomaly to/from the same IP, using the same decoder
21	Classification	String	`{classification}`	Console users can manually classify anomalies in Reports » Tools » Anomalies. Returns *Unclassified*, *False Positive, Possible Attack, Trivial Attack, Verified Attack* or *Crippling Attack*
23	Anomaly Description	String	`{anomaly}`	Describes the condition that triggered the traffic anomaly
24	Anomaly ID	Number	`{anomaly_id}`	Unique identification number of the anomaly
25	Anomaly Comment	String	`{comment}`	User-submitted comment about the anomaly
26	Direction	String	`{direction}`	Direction of the threshold rule that triggered the anomaly. Can be *incoming* or *outgoing*
27	N/A	String	`{direction_to_from}`	Returns *to* for inbound anomalies or *from* for outbound anomalies
28	N/A	String	`{direction_receives_sends}`	Returns *receives* for inbound anomalies or *sends* for outbound anomalies
29	Domain	String	`{domain}`	Returns *IP* when CIDR mask = 32 for IPv4 or 128 for IPv6, *subnet* in all other cases
30	Anomaly Class	String	`{class}`	Returns *threshold* for threshold-based anomalies and *profile* for profiling-based anomalies
31	Threshold Type	String	`{threshold_type}`	Threshold-based anomalies can be defined with *absolute* values or as a *percentage* of the total traffic received by Sensor
32	Anomaly Decoder (Protocol)	String	`{decoder}`	Returns the traffic decoder (protocol) used to detect the anomaly
33	Comparison	String	`{operation}`	Returns the comparison function used by the threshold rule, *over* or *under*
34	N/A	String	`{comparison}`	Returns ">" for traffic rates exceeding the threshold or "<" for traffic rates under the threshold
35	Unit	String	`{unit}`	Returns *pkts/s* for threshold defined for packets per second, or *bits/s* for threshold defined for bits per second
36	Threshold Value	Number*	`{rule_value}`	Traffic value configured as threshold

37	Computed Threshold	Number*	`{computed_threshold}`	Value of the threshold, dynamically adjusted for profiling-based and percentage-based anomalies
38	Peak Packets/s	Number*	`{anomaly_pps}`	Highest packets/s rate of the anomaly
39	Peak Bits/s	Number*	`{anomaly_bps}`	Highest bits/s rate of the anomaly
40	Latest Packets/s	Number*	`{latest_anomaly_pps}`	Latest packets/s rate of the anomaly
41	Latest Bits/s	Number*	`{latest_anomaly_bps}`	Latest bits/s rate of the anomaly
42	Peak Value	Number*	`{value}`	Highest value of the abnormal traffic. Returns pkts/s or bits/s, depending on the threshold's unit
43	Latest Value	Number*	`{latest_value}`	Latest value of the abnormal traffic. Returns pkts/s or bits/s, depending on the threshold's unit
44	Sum Value	Number*	`{sum_value}`	For pkts/s thresholds returns the number of packets counted during the anomaly. For bits/s thresholds returns the number of bits counted during the anomaly
45	Peak Rule Severity	Number	`{severity}`	Returns the ratio between the peak abnormal traffic rate and the threshold value
46	Latest Rule Severity	Number	`{latest_severity}`	Returns the ratio between the latest abnormal traffic rate and the threshold value
47	Peak Link Severity	Number	`{link_severity}`	Returns the ratio between the peak abnormal traffic rate and the interface's traffic rate
48	Latest Link Severity	Number	`{latest_link_severity}`	Returns the ratio between the latest abnormal traffic rate and the interface's traffic rate
49	Latest Link Utilization	Number	`{latest_link_utilization}`	Returns the ratio between the latest total traffic rate and the interface's traffic rate
50	N/A	String	`{anomaly_log_10}`, `{anomaly_log_50}`, `{anomaly_log_100}`, `{anomaly_log_500}`, `{anomaly_log_1000}`	Returns 10/50/100/500/1000 packets (if a packet capturing action is enabled in the Response) or flows (if Flow Collector is enabled) with the anomalous traffic
51	Custom Script Return Value	Number	`n/a`	This conditional parameter is true only when the script entered in the Value field returns status 0 after its execution. The comparison field must be set to equal. You can pass dynamic parameters as arguments for the script
52	N/A	String	`{software_version}`	Wanguard version

TIME PARAMETERS				
#	**CONDITIONAL PARAMETER**	**TYPE**	**DYNAMIC PARAMETER**	**DESCRIPTION**
1	From	Number	`{from_unixtime}`	Start time of the anomaly, in unixtime format (number of seconds since Jan 1st 1970)
2	Until	Number	`{until_unixtime}`	Expiration time of the anomaly, in unixtime format
3	From	String	`{from},{from_year},{from_month},{from_day},{from_dow},{from_hour},{from_minute}`	Start time of the anomaly, in iso8601 format (YYYY-MM-DD) or by year, month, etc.
4	Until	String	`{until},{until_year},{until_month},{until_day},{until_dow},{until_hour},{until_minute}`	Stop time of the anomaly, in iso8601 format (YYYY-MM-DD) or by year, month, etc.
5	Duration	Number	`{duration}`	Duration of the anomaly, expressed in seconds
6	N/A	String	`{duration_clock}`	Text string describing the duration of the anomaly. Examples: <5sec, 5h 4h 3s
7	N/A	String	`{duration_clock_full}`	Text string describing the duration of the anomaly. Examples: <5 seconds, 5 hours 4 minutes 3 seconds
8	Internal Ticks	Number	`{tick}`	Sensor's internal tick. For Packet Sensor 1 tick = 5 seconds. For Flow Sensor 1 tick = the value of the Granularity parameter

OVERALL TRAFFIC PARAMETERS				
#	**CONDITIONAL PARAMETER**	**TYPE**	**DYNAMIC PARAMETER**	**DESCRIPTION**
1	Peak IP Pkts/s	Number*	`{total_pps}`	Peak IP packets/s rate for the prefix
2	Peak IP Bits/s	Number*	`{total_bps}`	Peak IP bits/s rate for the prefix
3	Latest IP Pkts/s	Number*	`{latest_total_pps}`	Latest IP packets/s rate for the prefix
4	Latest IP Bits/s	Number*	`{latest_total_bps}`	Latest IP bits/s rate for the prefix
5	IP Packets	Number*	`{sum_total_pkts}`	Number of IP packets counted during the anomaly
6	IP Bits	Number*	`{sum_total_bits}`	Number of IP bits counted during the anomaly

FILTER PARAMETERS				
#	**CONDITIONAL PARAMETER**	**TYPE**	**DYNAMIC PARAMETER**	**DESCRIPTION**
1	Filter Name	String	`{filter}`	Returns the name of the Filter that detected the filtering rule
2	Filter ID	Number	`{filter_id}`	Unique ID of the Filter that detected the filtering rule

3	Filter Type	String	`{filter_type}`	Type of Filter: Packet Filter, Flow Filter, Filter Cluster
4	Filter Group	String	`{filter_group}`	Device Group configured in the Filter configuration
5	Number of Filters	Number	`{filters}`	Number of Filter instances activated for the anomaly
6	Filters Pkts/s	Number*	`{filters_pps}`	Returns the most recent packets/s rate recorded by the Filter instances activated for the anomaly
7	Filters Bits/s	Number*	`{filters_bps}`	Returns the most recent bits/s rate recorded by the Filter instances activated for the anomaly
8	Filters Max Pkts/s	Number*	`{filters_max_pps}`	Maximum packets/s rate recorded all Filter instances activated for the anomaly
9	Filters Max Bits/s	Number*	`{filters_max_bps}`	Maximum bits/s rate recorded all Filter instances activated for the anomaly
10	Filtered Packets	Number*	`{filters_filtered_packets}`	Number of packets blocked by all Filter instances activated for the anomaly
11	Filtered Bits	Number*	`{filters_filtered_bits}`	Number of bits blocked by all Filter instances activated for the anomaly
12	Filters CPU Usage	Number	`{filters_max_cpu_usage}`	Maximum CPU% used by the Filter instances activated for the anomaly

FILTERING RULE PARAMETERS

#	CONDITIONAL PARAMETER	TYPE	DYNAMIC PARAMETER	DESCRIPTION
1	Filtering Rule #	Number	`{filtering_rule_id}`	Unique ID of the filtering rule
2	Filtering Rule Type	String	`{filtering_rule_type}`	What type of filtering rule. All types are listed under Configuration » General Settings » Anomaly Mitigation
3	Filtering Rule Value	String	`{filtering_rule_value}`	Specific value of the filtering rule (specific IP, port number, protocol number, etc.)
		String	`{filtering_rule_ip_dns}`	When the filtering rule type is IP, it returns its reverse DNS
4	Filtering Rule ISP	String	`{filtering_rule_ip_isp}`	When the filtering rule type is IP, it returns the corresponding organization or Internet Service Provider
5	Filtering Rule Country	String	`{filtering_rule_ip_country}`	When the filtering rule type is IP, it returns its country
6	Filtering Rule Pkts/s	Number*	`{filtering_rule_pps}`	Latest packet/s rate for the traffic matched by the filtering rule
7	Filtering Rule Bits/s	Number*	`{filtering_rule_bps}`	Latest bits/s throughput for the traffic matched by the filtering rule

8	Filtering Rule Peak Pkts/s	Number*	`{filtering_rule_max_pps}`	Maximum packet/s rate for the traffic matched by the filtering rule
9	Filtering Rule Peak Bits/s	Number*	`{filtering_rule_max_bps}`	Maximum bits/s throughput for the traffic matched by the filtering rule
10	Filtering Rule Unit/s	Number*	`{filtering_rule_unit}`	Returns {filtering_rule_pps} for packets/s thresholds and {filtering_rule_bps} for bits/s thresholds
11	Filtering Rule Peak Unit/s	Number*	`{filtering_rule_max_unit}`	Returns {filtering_rule_max_pps} or {filtering_rule_max_bps} depending on the unit of the threshold
12	Filtering Rule Severity	Number	`{filtering_rule_severity}`	Returns the ratio between the traffic matched by the filtering rule and the threshold's value
13	Filtering Rule Packets	Number*	`{filtering_rule_packets}`	Returns the number of packets matched by the filtering rule
14	Filtering Rule Bits	Number*	`{filtering_rule_bits}`	Returns the number of bits matched by the filtering rule
15	Filtering Rule Time Interval	Number	`{filtering_rule_difftime}`	Duration while the filtering rule was detected
16	Filtering Rule Whitelist	Number	`{filtering_rule_whitelisted}`	When the filtering rule is whitelisted, returns 1. Otherwise returns 0
17	Filtering Rule Traffic Sample Size	Number*	`{filtering_rule_log_size}`	If the Response contains an action to capture the packets matched by the filtering rule, returns the packet dump's size in bytes
18	N/A	String	`{attacker_isp}`	When the filtering rule type is IP, it returns the email address of the attacker's ISP, as found in the whois database
19	N/A	String	`{filtering_rule_log_10}`, `{filtering_rule_log_50}`, `{filtering_rule_log_100}`, `{filtering_rule_log_500}`, `{filtering_rule_log_1000}`	Returns 10/50/100/500/1000 packets of the traffic matched by the filtering rule if the Response contains an action for capturing packets

* All numbers are integers. Numerical values can be returned in multiples of 1,000 by appending `_kilo` to the dynamic parameter. The same goes for 1,000,000 by appending `_mega` and for 1,000,000,000 by appending `_giga`. To get the biggest multiplier (k, M, G) for the value, append `_prefix`. To also return the decoder before the biggest multiplier (k, M, G) value, append `_decoder_prefix`.

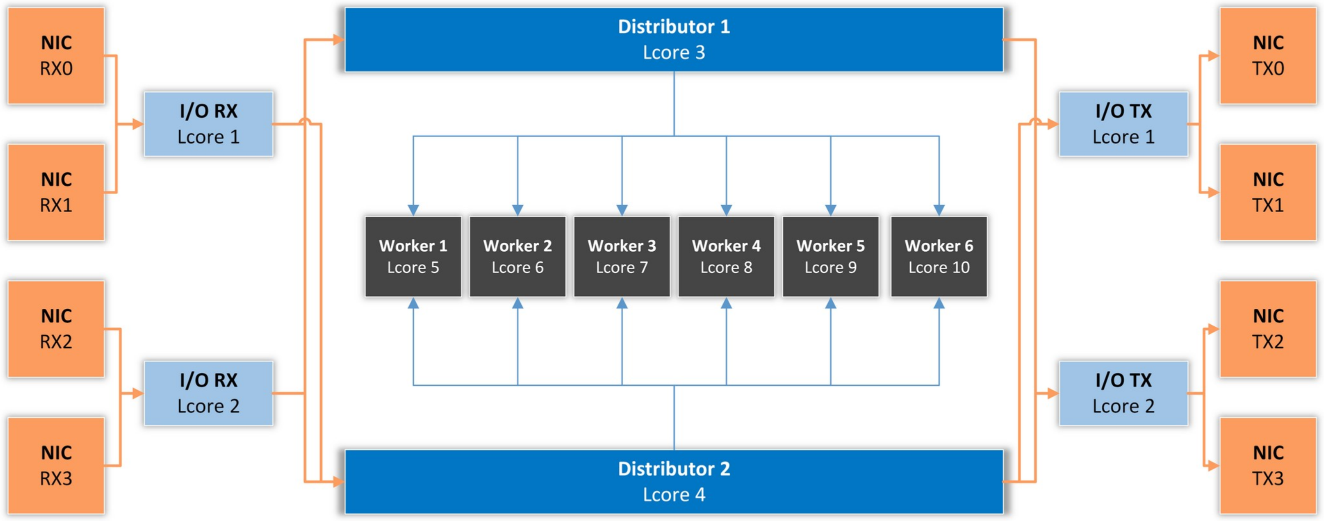
Appendix 6 – DPDK Configuration

Wanguard 8.0 supports DPDK version 19.11.2 on Intel microarchitectures starting with Sandy Bridge (Ivy Bridge, Haswell, Broadwell, Skylake, etc.). The code is currently optimized for Broadwell. NICs that need special drivers for DPDK (e.g. Mellanox) might not be supported. For other limitations of DPDK please consult the table from page 10.

To use DPDK 19.11.2, follow the installation guide from http://www.dpdk.org and allocate at least 8 hugepages each with 1 GB page size. There are several BIOS optimization settings required, as well as a number of kernel parameters that increase the performance of the server. It may be possible to purchase preconfigured appliances, already optimized for DPDK, from https://www.andrisoft.com/hardware/anti-ddos-appliance.

Application Workflow

The architecture of the application is similar to the one presented in the following diagram which illustrates a specific case of two I/O RX and two I/O TX lcores (logical CPU cores) off-loading the packet Input/Output overhead incurred by four NIC ports, with each I/O lcore handling RX/TX for two NIC ports. The RX lcores are dispatching the packets toward two Distributor cores which are distributing them to six Worker lcores.



I/O RX Lcore performs packet RX from the assigned NIC RX rings and then dispatches the received packets to one or more distributor lcores using RSS or a round-robin algorithm.

Distributor Lcore reads packets from one or more I/O RX lcores, extracts packet metadata, performs the Dataplane firewall's functionality, and dispatches packet metadata to one or more Worker lcores.

Worker Lcore performs the most heavy weight and CPU-intensive tasks such as traffic analysis and attack detection.

I/O TX Lcore performs packet TX for a predefined set of NIC ports. The packets are forwarded in batches of minimum 4, so the latency will be very high (>50 ms!) if the application forwards just a few packets per second. On thousands of packets/s the latency falls well under 1 millisecond.

The application needs to use one **Master Lcore** to aggregate data from the workers.

DPDK Capture Engine Options

- **EAL Options** – See the DPDK Getting Started Guide for more information on this mandatory parameter
- **RX Parameters** – The syntax is "(PORT,QUEUE,LCORE).." and represents a list of NIC RX ports and queues handled by the I/O RX lcores. This parameter also implicitly defines the list of I/O RX lcores. This is a mandatory parameter
- **Distributor Mode** – Specify the algorithm used to dispatch packets from the RX to the Distributor lcores:
  - *Round-robin* – The load is shared equally between the Distributor lcores. This is the best option when the packets are not forwarded
  - *RSS* – The packets with the same RSS value are always dispatched to the same Distributor lcore. This is the best option when packets are forwarded, mainly because it maintains the order of the packets
  - *Custom* – Select this option to be able to specify the Distributor lcore for each RX port. In this case, the RX Parameters syntax becomes "(PORT,QUEUE,LCORE,DISTRIBUTOR_LCORE_NO).."
- **Distributor Lcores** – Enter the lcore of the Distributor thread, or a list of lcores separated by comma. This is a mandatory parameter
- **Worker Lcores** – The list of worker lcores. This is a mandatory parameter
- **Master LCORE** – Set an lcore to be used exclusively for thread management purposes. The recommended value is the hyper-thread core of CPU 0 because its performance is not important. This is a mandatory parameter
- **Forwarding Mode** – Specify the TX functionality:
  - *Disabled* – The packets are not forwarded, so the application behaves like a passive sniffer
  - *Transparent Bridge* – All Ethernet frames are forwarded without any intervention, so the application works like a transparent bridge. This is the fastest forwarding method.
  - *IP Forwarding* – The application performs several tasks for each packet. If it's an ARP packet querying for the MAC address of one of the interfaces defined below it responds to that query. On all other packets, it rewrites the source MAC address with the output interface MAC, and it rewrites the destination MAC with the MAC address defined below. The application is not performing RFC 1812 checks and is not decreasing the TTL value. This forwarding method is necessary when the server is deployed out-of-line with traffic redirected by BGP. For latency considerations see the previous option
- **TX Parameters** – The syntax is "(PORT,LCORE).." and it defines a list of NIC TX ports handled by the I/O TX lcores. This parameter also implicitly defines the list of I/O TX lcores. This parameter is mandatory when the Forwarding Mode is not set to Disabled
- **Forwarding Table** – The syntax is "(PORT_IN,PORT_OUT).." and it defines the output interface depending on the input interface
- **Interface IPs** – The syntax is "(PORT,IPV4).." and it defines the IP of each port. This parameter is used when the Forwarding Mode is set to IP Forwarding but it does not ensure a true TCP/IP stack on the interface. The application will respond to ARP requests, but it's highly recommended to set the ARP table manually on the router because the application could respond to ARP requests with a high delay due to bulk processing

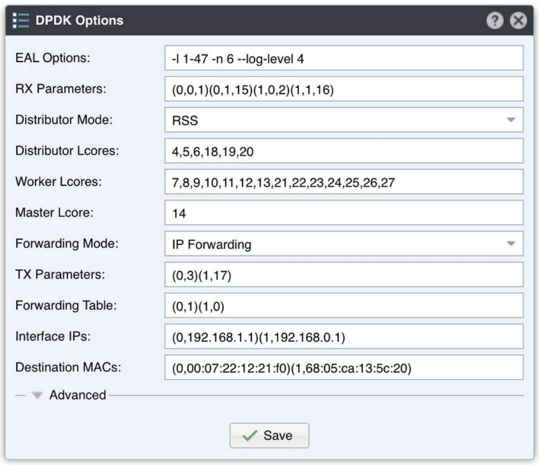
- **Destination MACs** – The syntax is “(PORT,MAC_ADDRESS)..” and it defines the gateway MAC address for each port. This option is used when the Forwarding Mode is set to IP Forwarding
- **Maximum Frame Size** – If the network uses jumbo frames, enter the maximum frame size (usually 9000). Otherwise the default value is 1518, which captures normal Ethernet frames
- **IP Hash Table Size** – By default, the IPs are tracked using a hash table with 524288 elements for each worker lcore, IP version and traffic direction
- **Int. IP Mempool Size** – The default value is 70000 which means that each worker lcore pre-allocates RAM space to hold traffic information for up to 70000 IPs. The mempool is refreshed every 1 to 5 seconds, so to reach this limit all hosts must send or receive traffic during this period. The RAM space required per IP is listed in Sensor Graphs by selecting the Data Unit “IP Structure RAM”
- **Ext. IP Mempool Size** – This mempool is used for recording traffic information for external IP addresses. The default value is 120000 per worker lcore
- **Ring Sizes** – The accepted format is “A, B, C, D”:
  - A = The size (in number of buffer descriptors) of each of the NIC RX rings read by the I/O RX lcores
  - B = The size (in number of elements) of each of the software rings used by the I/O RX lcores to send packets to worker lcores
  - C = The size (in number of elements) of each of the software rings used by the worker lcores to send packets to I/O TX lcores
  - D = The size (in number of buffer descriptors) of each of the NIC TX rings written by I/O TX lcores

    The default values are “1024, 1024, 1024, 1024” which are optimal for the Intel ixgbe driver. Other network controllers and/or drivers might use different values
- **Burst Sizes** – The accepted format is “(A, B), (C, D), (E, F)”.
  - A = The I/O RX lcore read burst size from NIC RX
  - B = The I/O RX lcore write burst size to the output software rings
  - C = The worker lcore read burst size from the input software rings
  - D = The worker lcore write burst size to the output software rings
  - E = The I/O TX lcore read burst size from the input software rings
  - F = The I/O TX lcore write burst size to the NIC TX

  The default values are “(144,144),(144,144),(144,144)” when Forwarding Mode is disabled, and “(8,8),(8,8),(8,8)” when Forwarding Mode is enabled. A burst size of 8 effectively means that the software will process at least 8 packets in parallel. So, on a traffic of 1 packet/s you will see a significant delay. It is not possible to use values less than 4 in DPDK 18.11 or 8 in DPDK 19.11

DPDK Configuration Example

Execute the script usertools/cpu_layout.py from the your dpdk directory to see the CPU layout of your server. The following configuration assumes this CPU layout of a 14-core Xeon processor: Core 0 [0, 14], Core 1 [1, 15], Core 2 [2, 16], Core 3 [3, 17], Core 4 [4, 18], Core 5 [5, 19], Core 6 [6, 20], Core 8 [7, 21], Core 9 [8, 22], Core 10 [9, 23], Core 11 [10, 24], Core 12 [11, 25], Core 13 [12, 26], Core 14 [13, 27].



EAL Options:	-l 1-47 -n 6 --log-level 4
RX Parameters:	(0,0,1)(0,1,15)(1,0,2)(1,1,16)
Distributor Mode:	RSS
Distributor Lcores:	4,5,6,18,19,20
Worker Lcores:	7,8,9,10,11,12,13,21,22,23,24,25,26,27
Master Lcore:	14
Forwarding Mode:	IP Forwarding
TX Parameters:	(0,3)(1,17)
Forwarding Table:	(0,1)(1,0)
Interface IPs:	(0,192.168.1.1)(1,192.168.0.1)
Destination MACs:	(0,00:07:22:12:21:f0)(1,68:05:ca:13:5c:20)

EAL Options contains the parameter “-l 1-27” which configures DPDK to use the lcores 1 to 27 (28 lcores = 14-core CPU with Hyper-threading enabled). The parameter “-n 4” configures DPDK to use 4 memory channels which is the maximum of what the reference Intel Xeon CPU (14-core Broadwell) supports.

The RX parameters configure the application to listen to the first two DPDK-enabled interfaces (0 and 1), on two NIC queues (0 and 1), and to use two CPU cores for this task (15 and 16 are the hyper-threads of cores 1 and 2).

The Distributor Mode setting ensures that the packets will be forwarded in the same order.

Three CPU cores are used for the Dataplane firewall and to distribute packets to the workers: 4, 5 and 6 (18, 19 and 20 are hyper-threads).

Seven CPU cores are used for packet analysis and attack detection: 7 to 13 (21 to 27 are hyper-threads).

The Master lcore is the hyper-thread of CPU core 0 which is used by the OS.

The TX parameters configure the application to use a single CPU core for TX. Lcore 3 sends packets over port 0, while the lcore 17 (hyper-thread of CPU core 3) sends packets over port 1.

The Forwarding Table value specifies that incoming packets on port 0 should be sent to port 1, and vice versa.

The next two parameters set the IPs and the destination MACs for both ports.