GÉANT
Networks • Services • People

SIG-NOC Tools Survey

What software tools R&E Operations Centres use

November 2019

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1. Introduction

The Special Interest Group – Network Operations Centres (SIG-NOC) is a community effort [1] initiated by the National Research and Education Networks (NRENs) gathered under the GÉANT Association in Europe. The SIG-NOC creates an open forum where experts from the GÉANT Community and beyond exchange information, knowledge, ideas and best practices. These cover specific technical aspects or other areas of business, relevant to the research and education networking community. The SIG-NOC is the successor of the former TERENA Task Force on NOCs (TF-NOC).

The SIG-NOC community has run 3 surveys since the creation of TF-NOC in 2010. The reason for running it from time to time is the need to keep up to date information for the Network Operation Centre community, because the tools and techniques used by the NOCs and the functions covered by them evolve. The first survey was published in 2012 [2] and it covered the NOCs' taxonomy, structures, resources, tools and other aspects. The second one was published in 2016 [3] and it was focused on tools, as it was the most relevant part for the SIG-NOC members. It also contained one section dedicated to the adoption of Standards and Industry best practices. The third survey, with the same focus as the second, was run in 2019.

Since the survey was mainly focusing on tools and operation practices, it was recommended to be filled out by someone who has an overview of the whole NOC's operations.

The questions in the survey were grouped in different sections, covering 16 major NOC functions: Monitoring, Problem management, Ticketing, Performance management, Reporting & statistics, Configuration management & backup, Communication, Coordination & Chat, Knowledge management/documentation, Change management, Out-of-Band Access, Security management, Inventory management, DDoS Mitigation, Resources management, Data aggregation, Representation & Visualisation and Orchestration, Automation & Virtualisation.

As an example of the evolution of the NOC's tasks, the 2012 survey contained 14 functions. In 2016, DDoS Mitigation was added to the list and, in 2019, Orchestration, Automation and Virtualisation were included.

The results of the 2019 survey are summarised in this report. The anonymized survey data is also available in MS Excel format for further analysis.

2. Survey Participants

We received 89 individual responses to the survey of which 63 were valid and fully or partly complete. Empty responses, invalid names and duplicated institutions were not considered (in case of more than one answer for a single institution, the most complete response was kept).

Chart 1 shows the type and range of networks that participated in the survey.

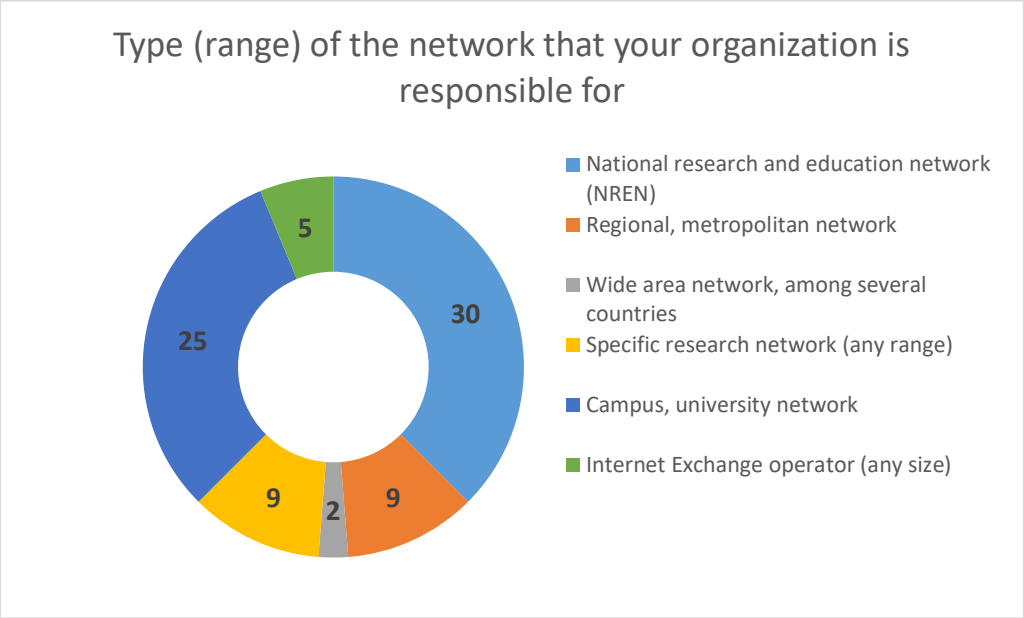

Chart 1. Type (range) of networks answering the survey

As in some cases the same NOCs may manage more than one type of network, the total number of types of networks (80) is more than the number of valid responses. Compared to the number of respondents to the previous surveys, the number of Campus Networks is the one that has experienced a larger increase. The number of NRENs and Specific research networks answering the survey has also increased.

Chart 2 shows a comparison of the networks that participated in each one of the surveys.[1]

[1] The results in the 2016 report for this question were considered as they were, without cleaning duplicates and invalid responses. In order to make a consistent comparison, the results of 2016 have been cleaned and recalculated following the same criteria as in 2019.

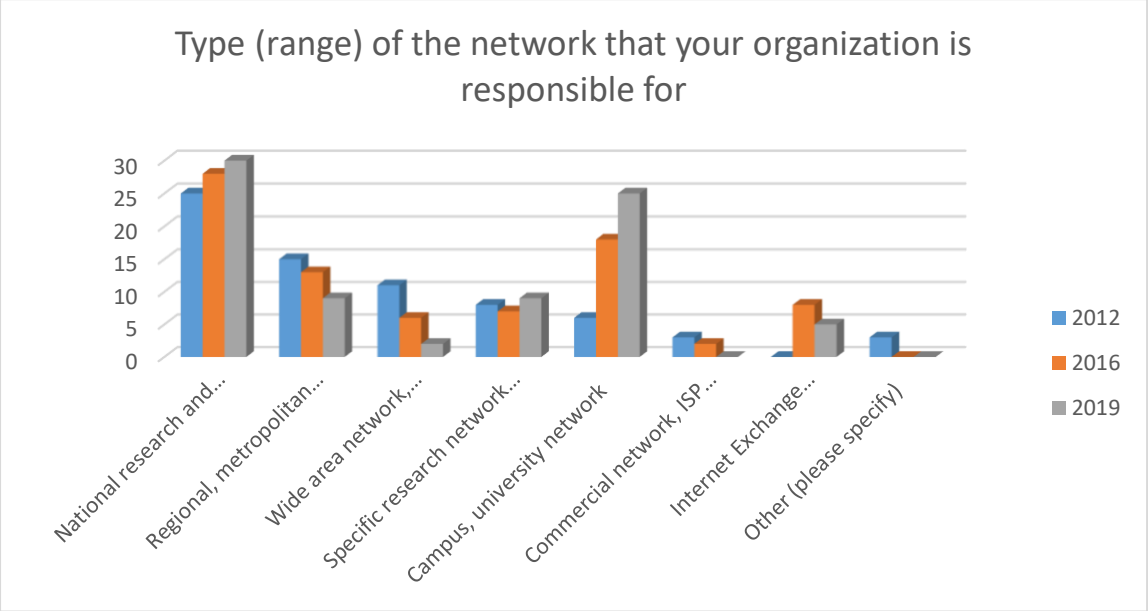

Chart 2. Type (range) of networks answering the survey

3. NOC Functions

The survey covered 16 functions that the NOCs may be responsible for. *Table 1* lists all the functions, sorted in the order of their importance rated by the respondents in 2019 and compared to the ranking in 2016. Monitoring, Problem Management and Ticketing keep the same three most relevant positions as in 2016. Reporting & Statistics and Configuration Management & Backup have the same number of responses considering they are NOC responsibilities, so they basically also stay in the same position. Performance Management drops, with one less response, which is not a significant drop. Change Management is the function that has dropped more positions in the table (4). The recently added function, Orchestration, Automation and Virtualisation is the least voted function, probably because the level of adoption in different institutions still varies, but more than 50% of the respondents that answered the question, considered that the NOC was responsible for it.

NOC Functions 2019	2019	2016	Trend
Monitoring	1	1	0
Problem Management	2	2	0
Ticketing	3	3	0
Reporting and Statistics	4	5	1
Configuration Management and Backup	5	6	1
Knowledge Management and Documentation	6	8	2
Performance Management	7	4	-3
Security Management	8	11	3
Inventory Management	9	12	3
Communication, Coordination and Chat	10	7	-3
Out-of-band Access Management	11	10	-1
Resources Management	12	14	2
Change Management	13	9	-4
DDoS Mitigation	14	13	-1
Data Aggregation, Representation, Visualization	15	15	0
Orchestration, automation and virtualisation	16		NEW

Table 1. Comparison of NOC functions

The 2019 data is also depicted in *Chart 3*. If we compare the number of respondents that considered each function as a NOC responsibility to the number of respondents that consider it is not their responsibility, all the functions are covered by more than 50% of the NOCs, with Monitoring as the function that most NOCs feel responsible for.

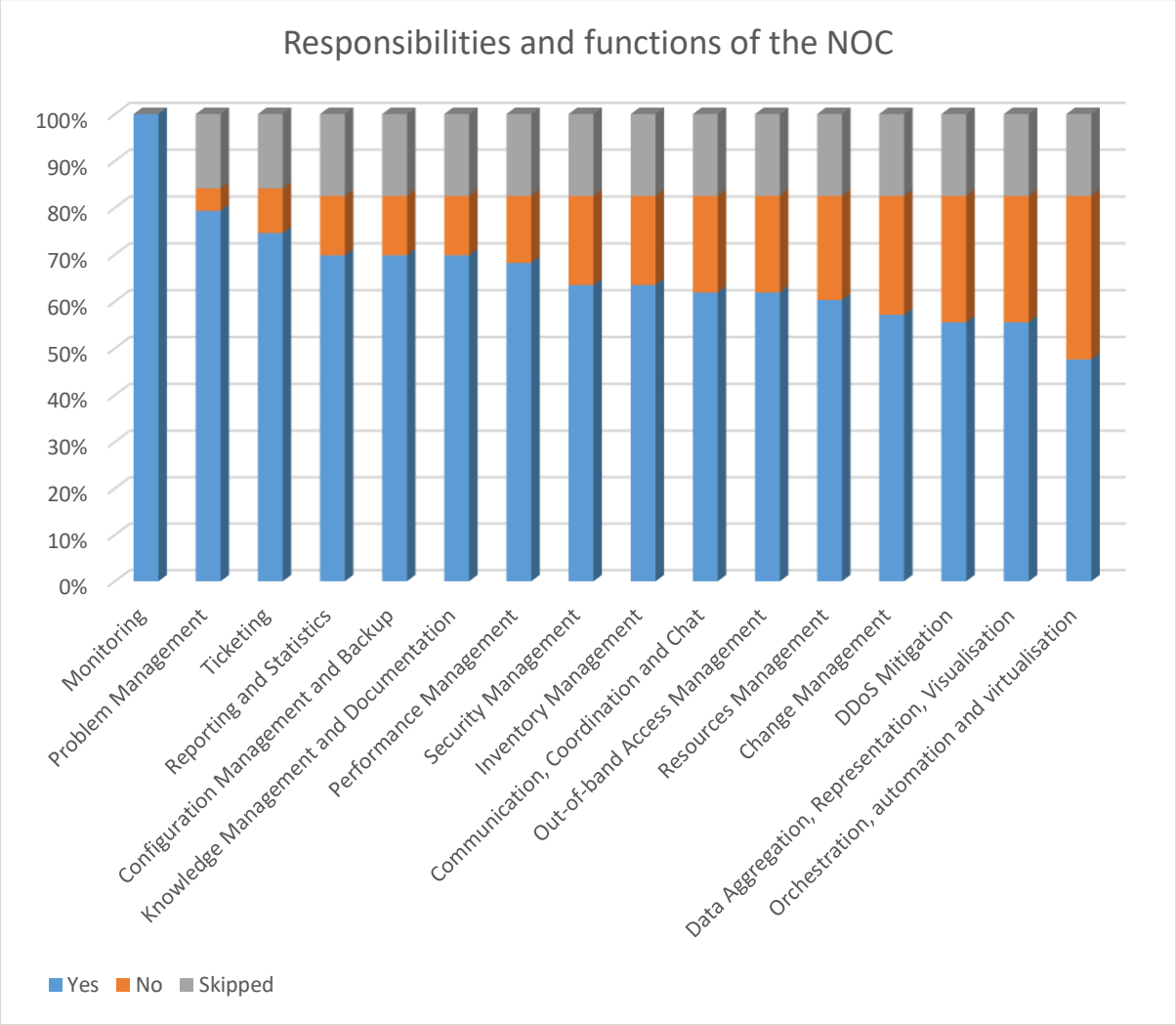

Chart 3. NOCs responsible for the particular functions

4. NOC Tools

In this chapter, the various software tools used to fulfil the particular functions rated by their importance and quality are shown. The importance is depicted horizontally, whereas the ratings (quality) are depicted vertically. The importance range goes from 1 (low) to 4 (high), while the rating goes from 1 (poor) to 5 (excellent). The size of the bubble indicates the number of answers that we got regarding that particular tool. The larger the circle, the more answers that we got for the tool. The smaller circles represent some tools that may be below or above average but bear in mind that this is based on the opinion of a smaller set of respondents only. We suggest taking into account the bigger bubbles or the ones with the same/similar relative sizes in any comparison.

The pre-defined responses in the survey were all the tools that were rated or mentioned by two or more respondents in the 2016 survey. There were also open boxes to include other tools, including in-house developed solutions, for each function. These responses are also included in separate tables.

Some trends are highlighted in the report, but the final conclusions are up to the reader!

4.1. Monitoring

In this edition of the survey, the first question about monitoring that appeared in the 2016 survey was split into two questions. Previously, monitoring methodologies (SNMP-based, Netflow-based, etc) were merged with tools. This way, it is easier to compare methodologies and tools separately. *Chart 4* shows the different methodologies used in the NOCs for monitoring. In this case, instead of comparing importance and rating, importance and frequency of usage are compared. The size of the bubble indicates the number of answers for that methodology. As shown in the graph, SNMP-based tools are the most relevant and most frequently used tools, closely followed by Syslog-handling and FlowMon-based tools. Streaming Telemetry appears in the graph for the first time, but it is not widely adopted among the NOCs yet, probably because it is only available in vendors systems very recently and is very new.

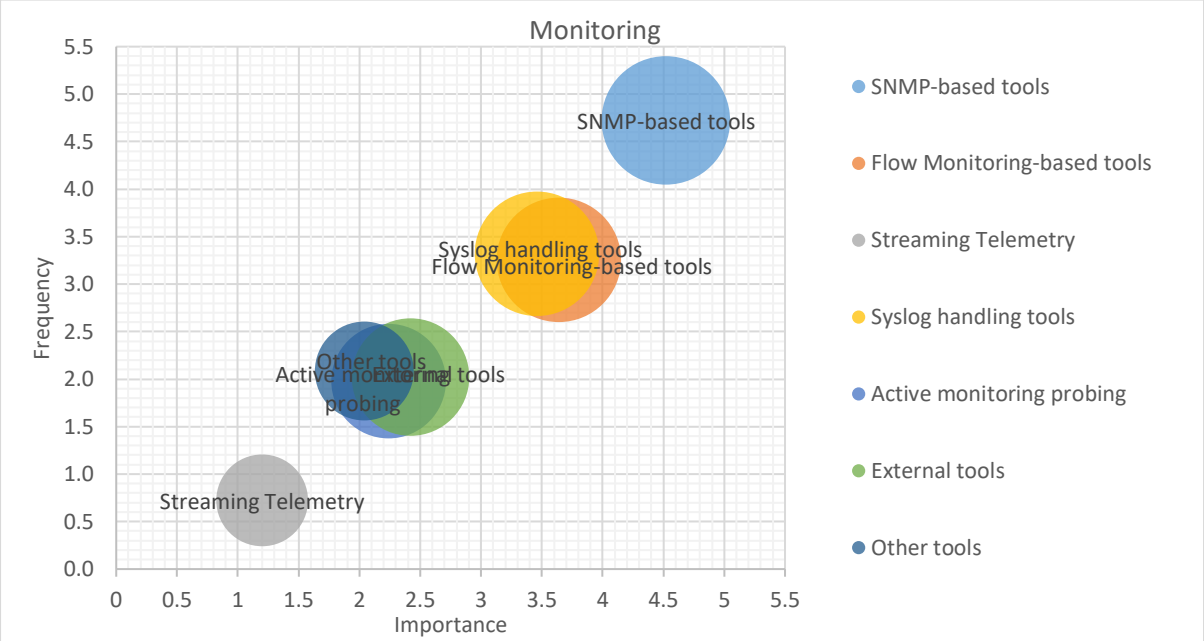

Chart 4. Software tools used for Monitoring

Chart 5 shows the software tools that NOCs use for Monitoring.

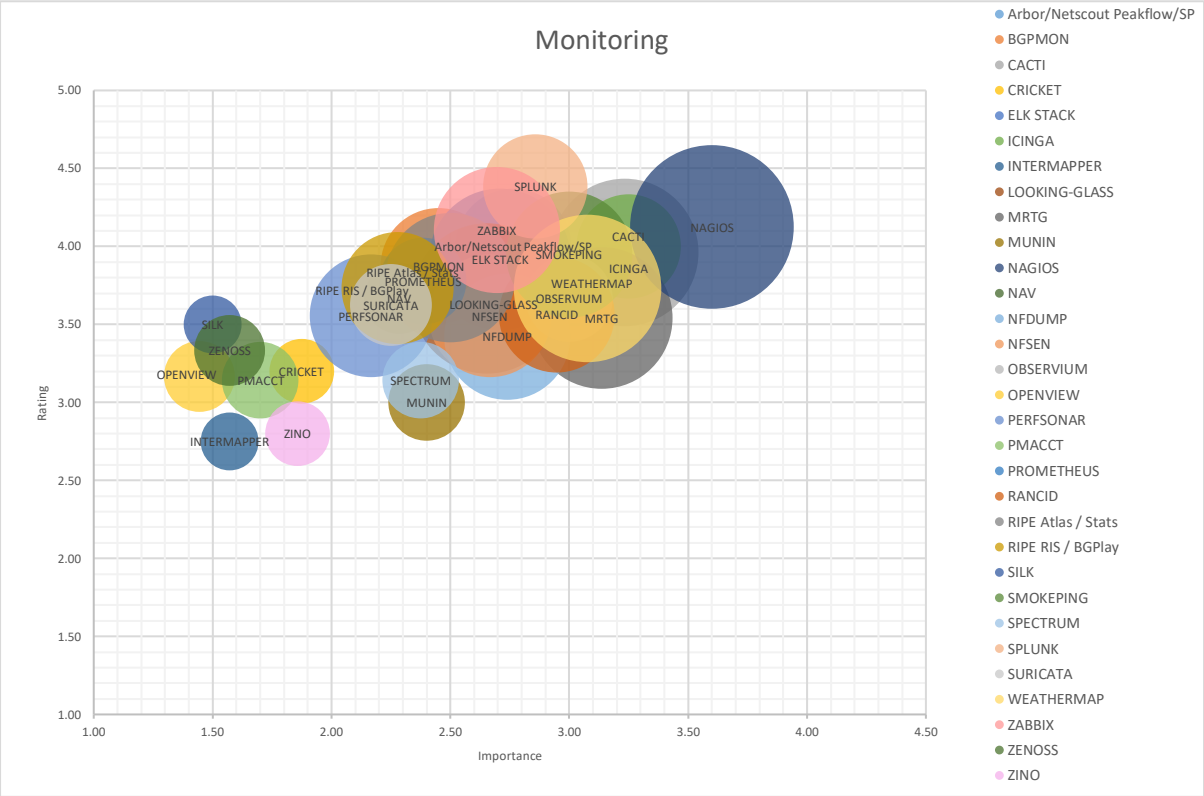

Chart 5. Software tools used for Monitoring

Nagios, Looking-glass and Cacti are the most widely used tools (based in the number of answers) and are also among the best valued tools for importance and quality, closely followed by the ELK stack tools, that appear for the first time in the monitoring section of the survey. Splunk gets the best rating, but it is used by less NOCs and the importance for them is around the average.

Table 2 shows the trends in the ranking for the Top-10 used software monitoring tools, comparing the position they occupy in the responses count table (sorting by number of answers for each tool).

Tool	2019	2016	Trend
NAGIOS	1	2	1
LOOKING-GLASS	2	3	1
CACTI	3	1	-2
WEATHERMAP	4	5	1
ELK STACK	5		NEW
MRTG	6	6	0
RIPE Atlas / Stats	7	4	-3
NFDUMP	8	14	6
SMOKEPING	9	9	0
ZABBIX	10		NEW

Table 2. Trends in Monitoring tools

The ELK stack tools appear in the 5th position in number of users and Nfdump is the tool that has experienced the highest increase in the ranking.

Table 3 below lists other tools and in-house developed solutions not pre-defined in the survey. The first 6 were mentioned more than once; the number of institutions that mentioned it is shown in parentheses. From the number of answers to "Other tools" and "In-house developed tools" in this question (67 tools/responses), it is clear that many institutions complement standard monitoring tools with their own scripts, commercial tools and in-house developed solutions.

Other tools	• Grafana (5) • InfluxDB / Influx stack (4) • LibreNMS (3) • Oxidized (4) • SMARTxAC (2) • Graylog (2) • Ail-framework • AirManager • Alerta • ALLOT Netxplorer • Ansible • Centreon • Ciena OneControl • Cisco PRIME • Corero • Dashing • ECI Lightsoft

	• EMMA • Extreme Management Center • Graphite • Infping • Intelmq • IPERF • IRIS (a South African Network Management Platform) • Nagvis • Netdisco • Nfsen-ng • Nokia OMS • Omnivista • OpenBMP/SNAS • OpenNMS • Request Tracker • Scrutinizer • Sysmondash • UNTANGLE NG FIREWALL
In-house developed solutions:	• Igor • FTAS • G3 • Inventory Monitor (for network only), • Licence manager • gofetch (fast snmp poller for influxdb written in go) • Misc snmp-tools and scripts • A lot of perl scripts and a Web interface • in house developed SNMP based NMS • GINS GARR Integrated Networking Suite • several statistic related scripts and collection tools • CPE autoconfig, • Black Wall, • Equipment inventory, • Megaconf, • AutoBH... • viaipe.rnp.br • Diverse monitoring scripts

Table 3. Other tools and in-house developed solutions for Monitoring

4.2. Problem Management

Chart 6 shows the software tools that NOCs use for Problem Management.

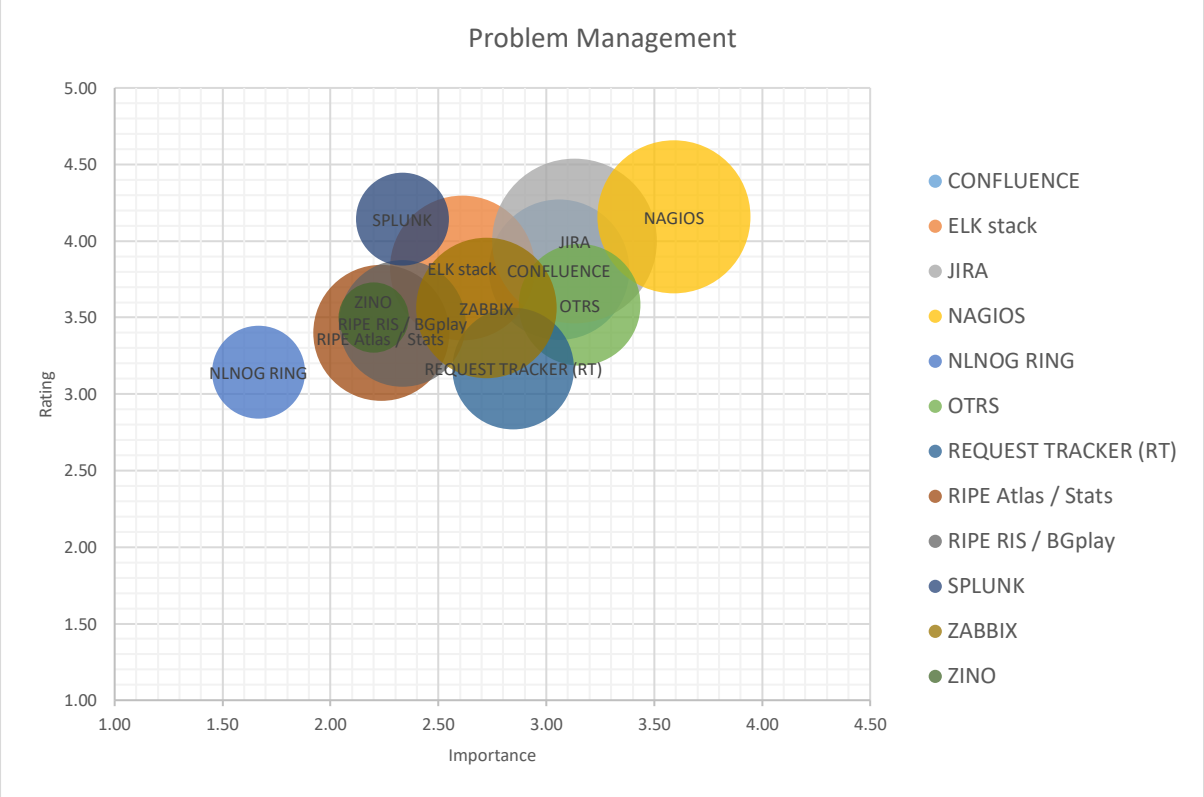

Chart 6. Software tools used for Problem Management

Jira, Nagios, and the ELK stack tools are rated the highest with relatively high importance and good ratings for quality. There are a few good tools useful for problem management but used by less institutions, such as Splunk or Zino.

Table 4 shows the tools and their usage ranking over the three-year period for Problem Management, comparing the position they occupy in the responses count table (sorting by number of answers for each tool). Jira has experienced the highest increase in the ranking, as it was in 11th position in 2016 and now it is the most used tool, followed by the ELK stack, that was in 9th position and is now in 3rd. Request tracker is the tool that has dropped most in the table, compared to 2016.

Tool	2019	2016	Trend
JIRA	1	11	10
NAGIOS	2	1	-1
ELK stack	3	9	6
CONFLUENCE	4		NEW
ZABBIX	5	8	3
RIPE Atlas / Stats	6	3	-3
RIPE RIS / BGplay	7	5	-2
OTRS	8	4	-4
REQUEST TRACKER (RT)	9	2	-7
NLNOG RING	10	7	-3

Table 4. Trends in Problem Monitoring Tools

Table 5 below lists other tools and in-house developed solutions not pre-defined in the survey for Monitoring. ServiceNow and OTRS are mentioned by 2 institutions.

Other tools:	• ServiceNow (2) • OTRS(2) • AirManager • CLI • Cricket • Gitlab (trouble tickets) • Grafana • Graylog • Icinga • Llibrenms • Netdisco • Nfsen • Omnivista • Openview Servicedesk • ProactivaNet • SpiceWorks
In-house developed solutions:	• Own PM Tool

Table 5. Other tools and in-house developed solutions for Problem management

4.3. Ticketing

Chart 7 shows the software tools that NOCs use for Ticketing.

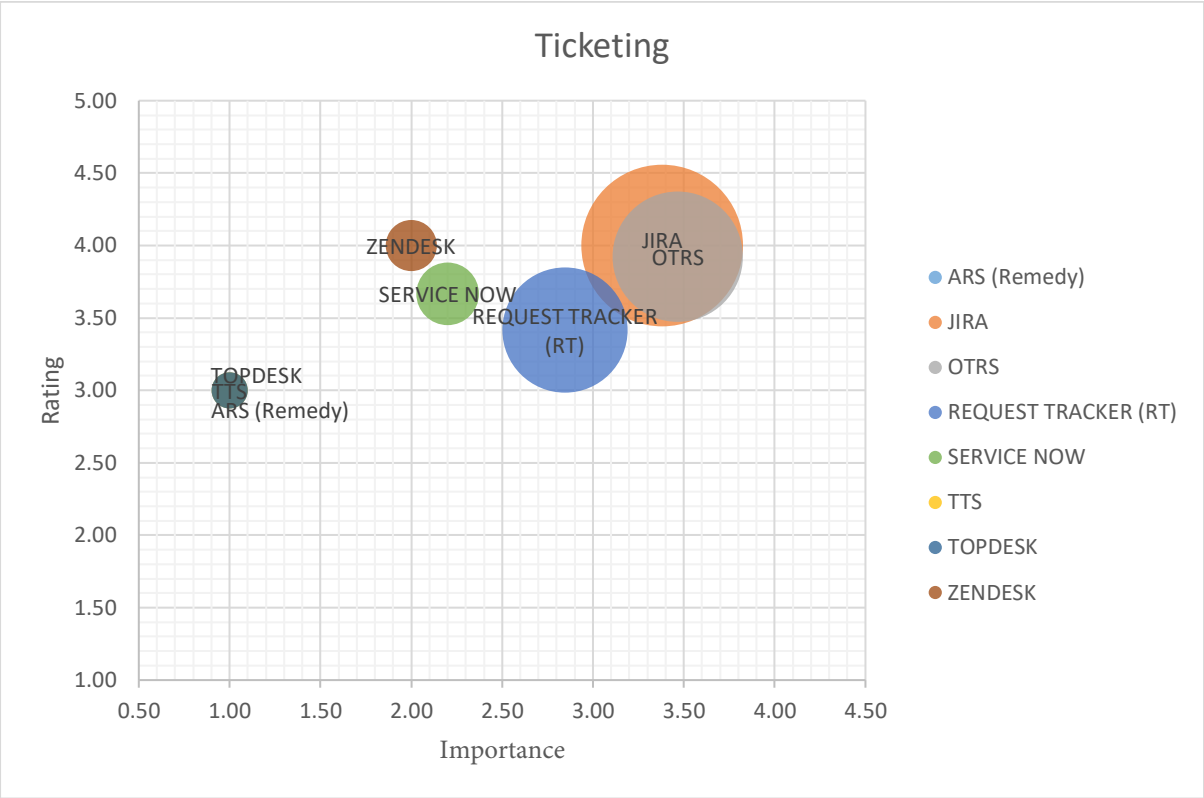

Chart 7. Software tools used for Ticketing

As in the previous section (Problem Monitoring), Jira is the most used software tool for Ticketing. In this case, it is followed by OTRS and Request Tracker (RT). All the other tools are mentioned by a significantly lower number of institutions.

Table 6 shows the trends in the ranking for all the software tools for Ticketing, comparing the position they occupy in the responses count table (sorting by number of answers for each tool). Jira has experienced an increase of 2 positions, while Request Tracker (RT) and ARS Remedy have dropped two positions, compared to 2016. OTRS remains in the second position.

Tool	2019	2016	Trend
JIRA	1	3	2
OTRS	2	2	0
REQUEST TRACKER (RT)	3	1	-2
SERVICE NOW	4	5	1
ZENDESK	5		NEW
ARS (Remedy)	6	4	-2
TTS	7	6	-1
TOPDESK	8		NEW

Table 6. Trends in Ticketing Tools

Table 7 below lists other tools and in-house developed solutions not pre-defined in the survey for Ticketing.

Other tools:	• CA Service Desk Manager • Gitlab • GLPI • Mantis • Openview ServiceDesk • ProactivaNet • ServiceDesk+ • Salesforce SpiceWorks • Trac
In-house developed solutions:	• e-mail (customer side), own PM tool (internally) • LAGUN • Ofbiz developed service • PHP in-house solution • TTS (trouble Ticket System)

Table 7. Other tools and in-house developed solutions for Ticketing

4.4. Reporting and Statistics

Chart 8 shows the software tools that NOCs use for Reporting and Statistics.

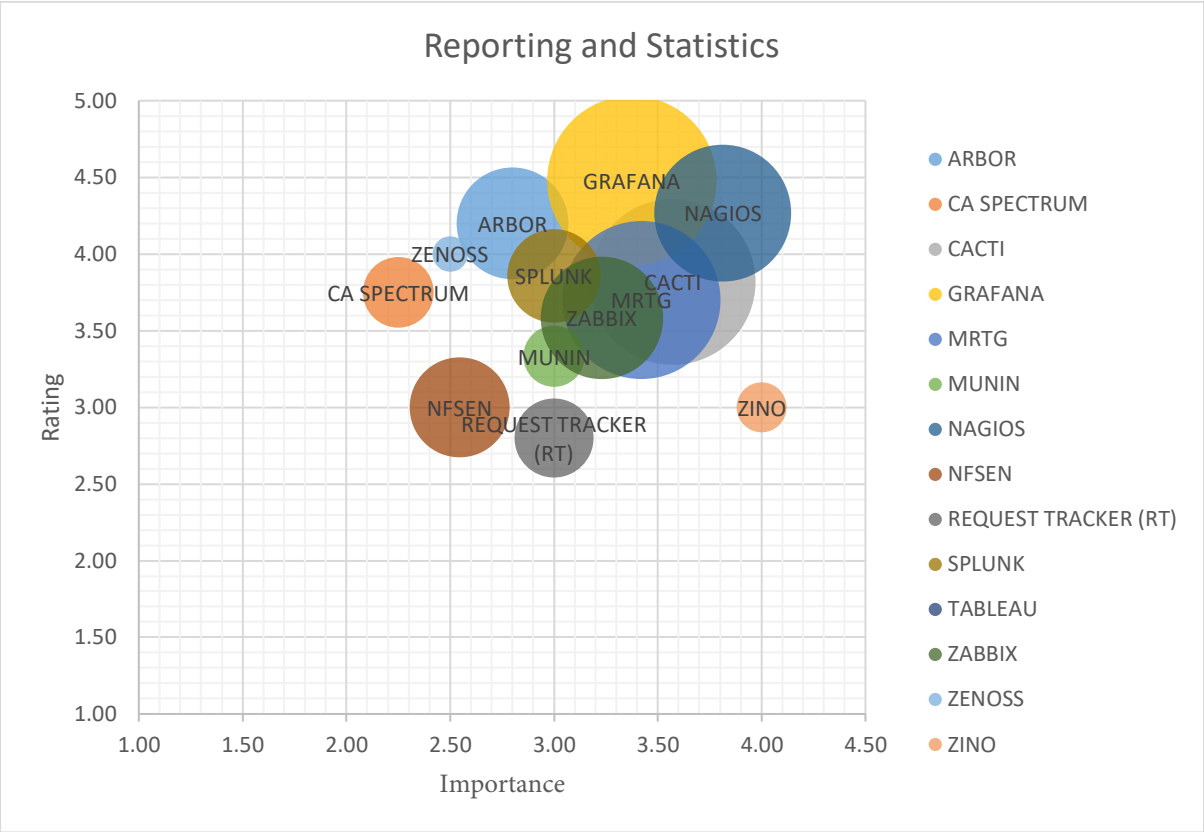

Chart 8. Software tools used for Reporting and Statistics

Grafana is the most commonly used tool, followed by Cacti and MRTG. Nagios is higher ranked both for quality and importance. Many other tools are perceived to have good value but are less used within the community.

Table 8 shows the trends in the ranking for the Reporting and Statistics tools, comparing the position they occupy in the responses count table (sorting by number of answers for each tool). Grafana and Zabbix experience the largest increase.

Tool	2019	2016	Trend
GRAFANA	1	5	4
CACTI	2	1	-1
MRTG	3	2	-1
NAGIOS	4	3	-1
ZABBIX	5	13	8
ARBOR	6	7	1
NFSEN	7	4	-3
SPLUNK	8	8	0
REQUEST TRACKER (RT)	9	12	3
CA SPECTRUM	10	11	1

Table 8. Trends in Reporting and Statistics tools

Table 9 lists other tools used by the community that were not pre-defined in the survey. LibreNMS and Observium were mentioned by 2 institutions.

Other tools:	• LibreNMS (2) • Observium (2) • AirManager • Icinga • IXP-manager • IRIS • MRTG ==> Cricket • NFSEN ==> FlowMon • Omnivista • OpenNMS • OTRS • Pnp4nagios • Scrutinizer • SQL Reporting services • Tablaeu
In-house developed solutions:	• ESnet NetBeam and Portal • GINS • Igor • Report module • Several statitistic collection and processing tools

Table 9. Other tools and in-house developed solutions for Reporting and Statistics

4.5. Configuration Management and Backup

The survey included questions for six Configuration and Management software tools. The results are shown in *Chart 9.*

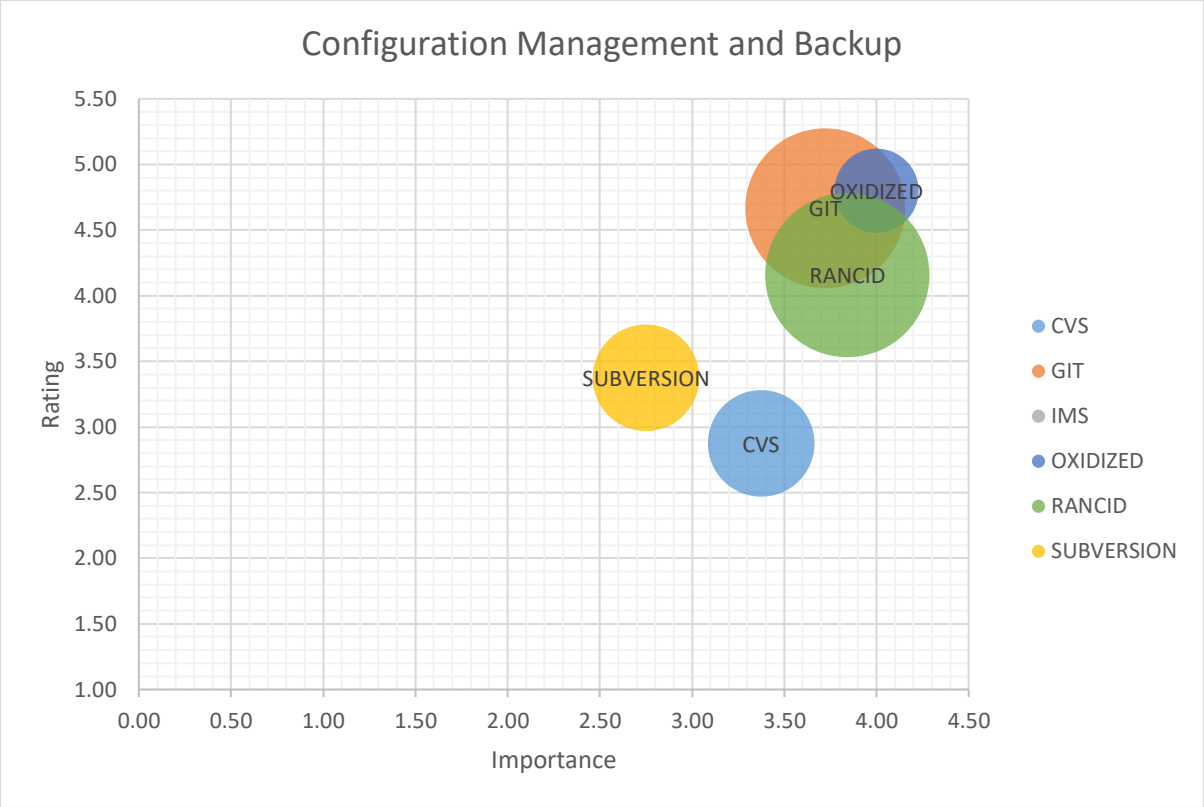

Chart 9. Software tools used for Configuration Management and Backup

Git and Rancid are the most commonly used tools. Rancid is perceived to be slightly more important than Git, while Git is better rated for the NOCs that answered the survey. Oxidized is not so broadly used, but it has the highest ratings.

Table 10 shows the usage trends of the different Configuration Management and Backup tools, comparing the position they occupy in the responses count table (sorting by number of responses for each tool).

Tool	2019	2016	Trend
RANCID	1	1	0
GIT	2	2	0
CVS	3	4	1
SUBVERSION	4	3	-1
OXIDIZED	5	6	1
IMS	6	5	-1

Table 10. Trends in Configuration Management and Backup Tools

Table 11 lists other tools used by the community which were not pre-defined in the survey.

Other tools:	• AirManager • Ansible • Backuppc • Dude • Extreme Management Center • FTP • HP IMC • Netdot • NOC Project • Rundeck • Omnivista • Prime-Infrastructure • Spectrum
In-house developed solutions:	• Automator (same as IROptika but still in developement) • Backitup tool • Backup scripts • CPE autoconfig • Extreme Management IROptika (generates network configs based on database states) • Local scripts • Megaconf • Perl scripts • Several scripts

Table 11. Other tools and in-house developed solutions for Configuration Management and Backup

4.6. Knowledge Management and Documentation

Chart 10 shows the software tools that NOCs use for Knowledge Management and Documentation.

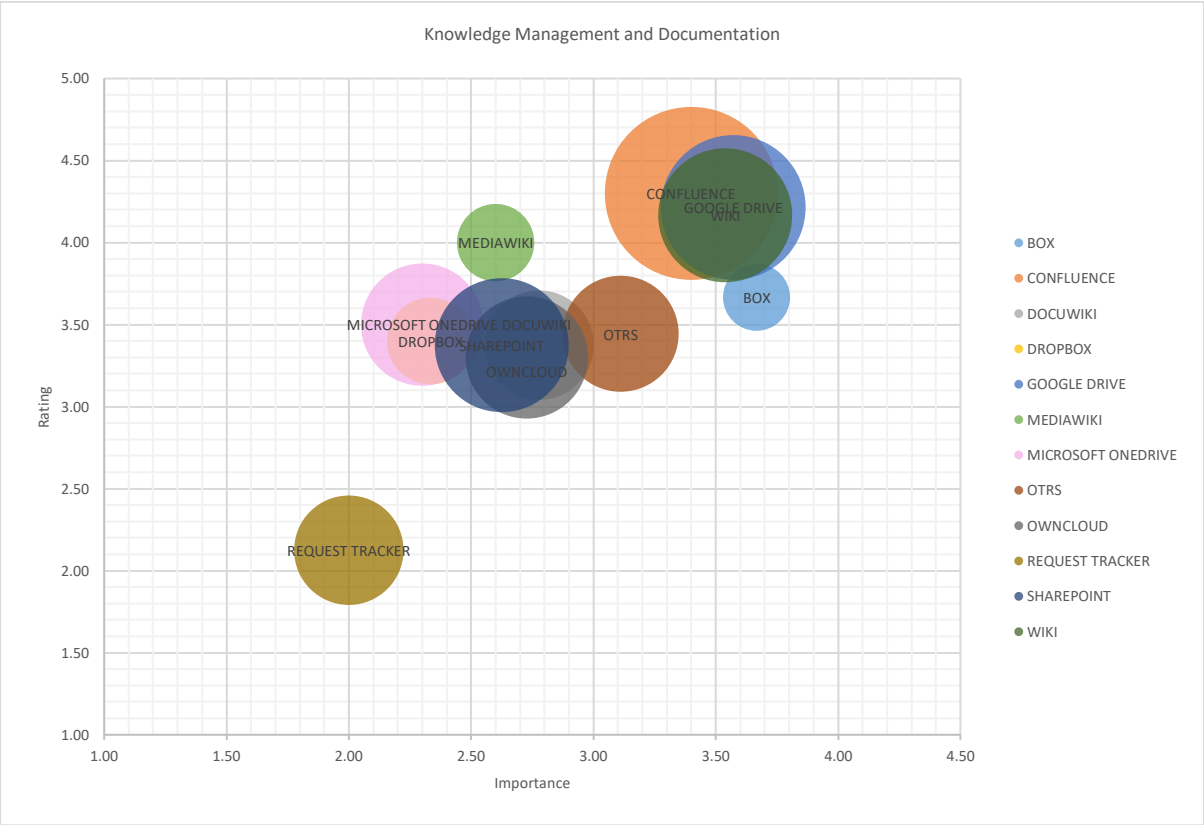

Chart 10. Software tools used for Knowledge Management and Documentation

Confluence is the most commonly used platform, followed by Google Drive and Wiki.

Table 12 shows the trends in the number of NOC that use the Top-10 software tools for Knowledge Management and Documentation, comparing the position they occupy in the responses count table (sorting by number of responses for each tool). This is one of the tables that has experienced more changes since the last survey, with tools like Confluence, Google Drive, Microsoft Onedrive or

Owncloud, that are being adopted by an increasing number of NOCs, while other tools are decreasing in the number of users. Many NOCs use more than one tool

Tool	2019	2016	Trend
CONFLUENCE	1	5	4
GOOGLE DRIVE	2		NEW
WIKI	3	1	-2
MICROSOFT ONEDRIVE	4	10	6
OWNCLOUD	5	9	4
OTRS	6	8	2
DOCUWIKI	7	6	-1
REQUEST TRACKER	8	3	-5
SHAREPOINT	9	7	-2
DROPBOX	10		NEW

Table 12. Trends in Knowledge Management and Documentation Tools

Table 13 lists other tools and in-house developed solutions that were not pre-defined in the survey for Knowledge Management and Documentation.

Other tools:	• Nextcloud (3) • Gitlab (2) (1: using trouble tickets as knowledge base; 2: private instance) • BSCW • Draw.io (Confluence plugin) • Gitbook • Ikiwiki • Microsoft Office • Moinmoin wiki. Not owncloud, but nextcloud! • Netbox • ServiceNow • XWIKI • VC4 IMS
In-house developed solutions:	• GARRBOX • OnlyOffice • Readthedocs • SAN / NAS

Table 13. Other tools for Knowledge Management and Documentation

4.7. Performance Management

Chart 11 shows the software tools that NOCs use to identify the source of performance problems in the network (Performance Management).

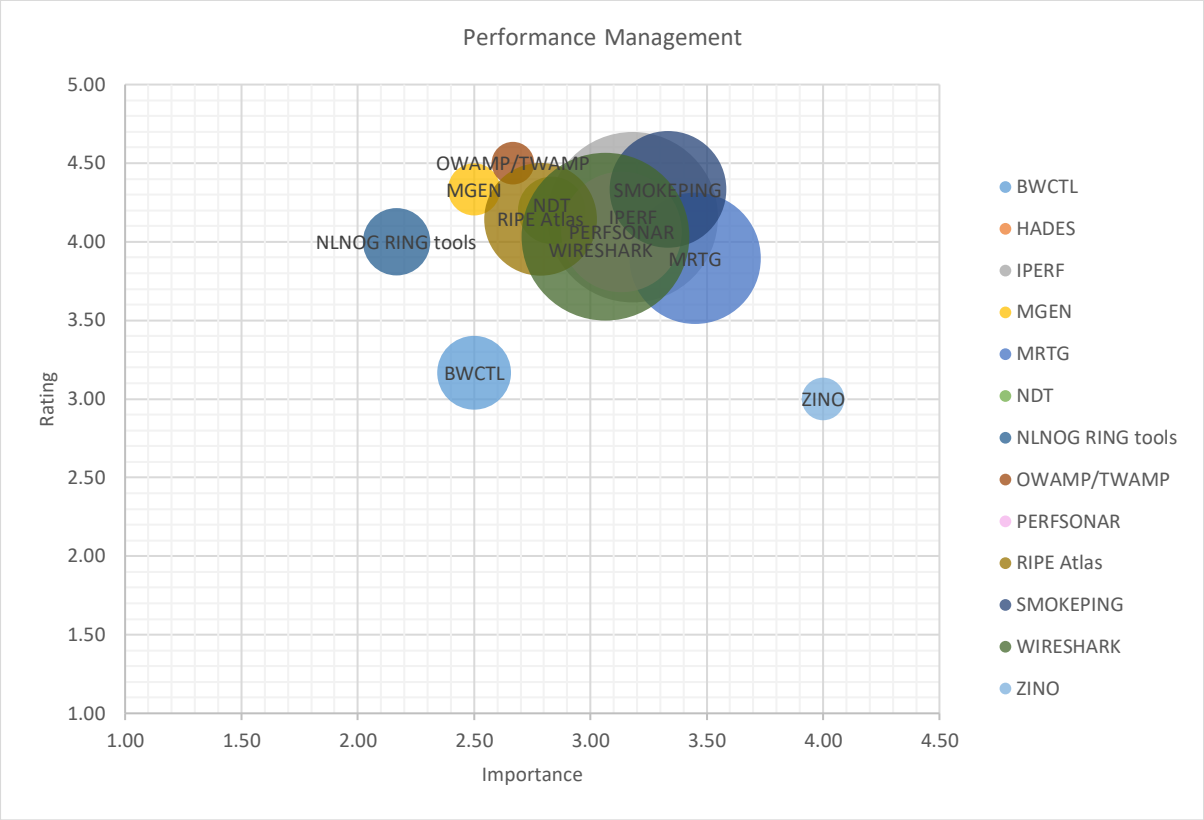

Chart 11. Software tools used for Performance Management

Performance Management tools are in general highly valued by NOCs. Iperf and Wireshark are the most commonly used tools. Smokeping and Mgen have a very high rating, although the number of users for Smokeping is more significant.

Table 14 shows the trends in the number of NOC that use the Top-10 software tools for Performance Management, comparing the position they occupy in the responses count table (sorting by number

of responses for each tool). This table shows no real trend changes since 2016. The first 6 tools in the list were in the same position in 2016.

Tool	2019	2016	Trend
IPERF	1	1	0
WIRESHARK	2	2	0
MRTG	3	3	0
PERFSONAR	4	4	0
SMOKEPING	5	5	0
RIPE Atlas	6	6	0
BWCTL	7	8	1
NDT	8	7	-1
NLNOG RING tools	9	9	0
MGEN	10	12	2

Table 14. Trends in Performance Management Tools

Table 15 lists other tools used by the community that were not pre-defined in the survey. Several types of speed tests are mentioned.

Other tools:	• AirManager • AKOStest (Slovenian speed test web app) • ALLOT Netxplorer • CA Performance Center • Cricket • Grafana • HawkEye • HTML5 speedtest • https://github.com/adolfintel/speedtest • Icinga • Nfsen • Mikrotik speedtest • Munin • Rude/ crude measurements • Scrutinizer • Speedtest • SNMP • Weathermap
In-house developed solutions:	• packETH https://github.com/jemcek/packETH • FTAS

	• Speed Test like tool • Bandwidth meter, • Predictive treshold (Zenoss)

Table 15. Other tools and in-house developed solutions for Performance Management

4.8. Security Management

Chart 12 shows the software tools that NOCs use for Security Management.

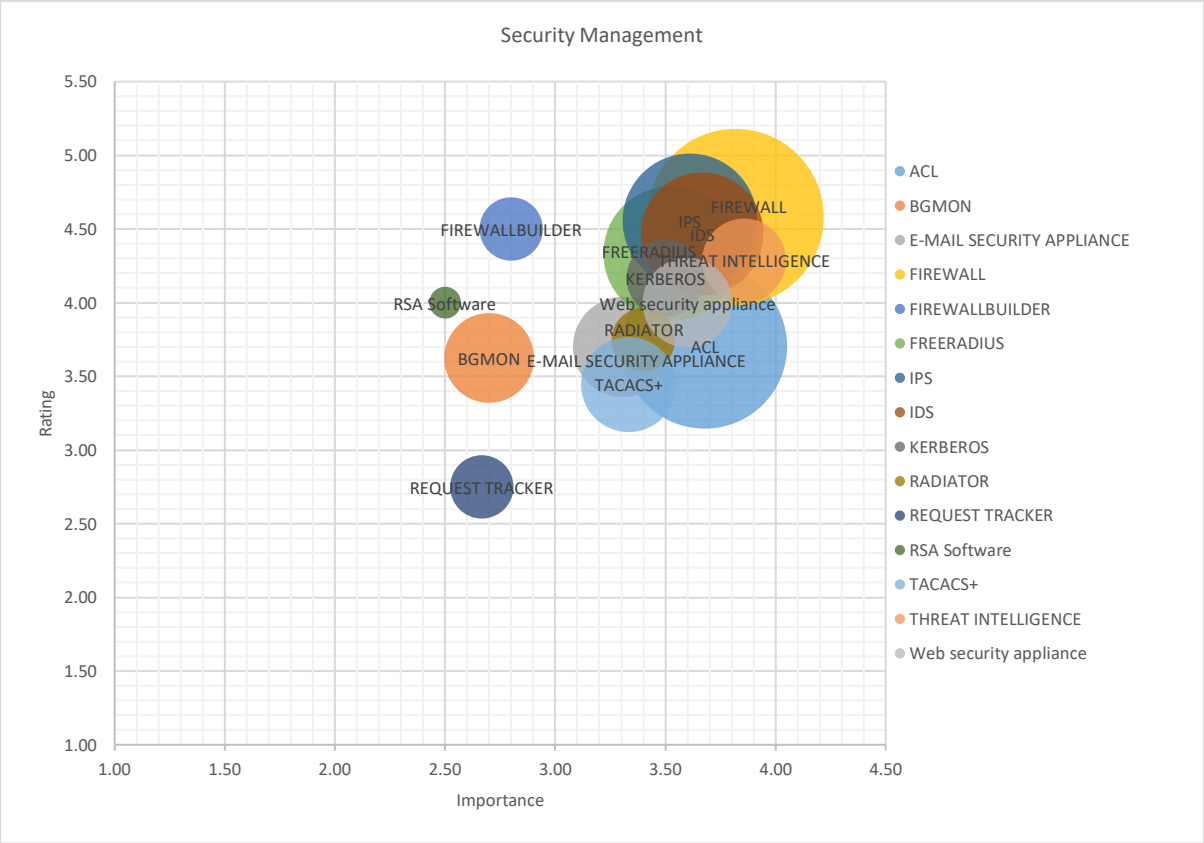

Chart 12. Tools used for Security Management

Firewall and ACL are still the most commonly used to handle security issues by the NOCs.

Table 16 shows the usage trends of the Security Management tools, comparing the position they occupy in the responses count table (sorting by number of responses for each tool). As this edition of

the survey contained several tools that appear in the questionnaire for the first time, many of the Top-10 used tools are new, compared to 2016. The top-3 ones, though, remain the same.

Tool	2019	2016	Trend
FIREWALL	1	1	0
ACL	2	2	0
FREERADIUS	3	3	0
IPS	4		NEW
IDS	5		NEW
E-MAIL SECURITY APPLIANCE	6		NEW
TACACS+	7	5	-2
BGMON	8	6	-2
Web security appliance	9		NEW
THREAT INTELLIGENCE	10		NEW

Table 16. Trends in Security Management Tools

Table 17 lists other tools used by the community that were not pre-defined in the survey. ClearPass appears twice. According to the responses, there are no in-house developments for Security Management.

Other tools:	• ClearPass (Aruba) (2) • AIL-Framework • AirManager • Anti-DDoS (F5 BigIP) • Cisco Umbrella • FortiAnalyzer • IntelMQ • Minemeld • RPKI • UNTANGLE NG FIREWALL

Table 17. Other tools for Security Management

4.9. Inventory Management

The survey included questions for six Inventory Management tools. The results are shown in *Chart 13*.

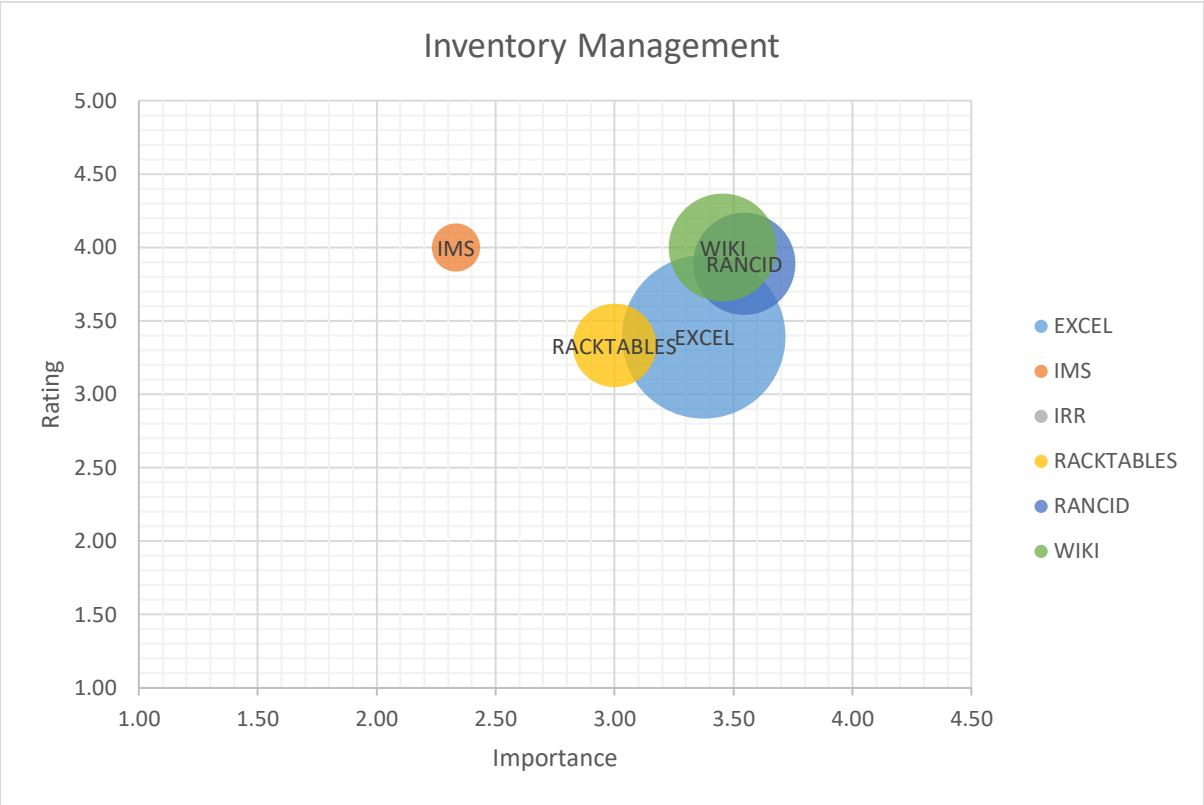

Chart 13. Software tools used for Inventory Management

Although Excel is the most popular tool, there are other tools that are more important or better rated, according to the responses.

Table 18 shows the trends in the number of NOC that use the software tools for Inventory Management, comparing the position they occupy in the responses count table (sorting by number of

responses for each tool). Excel is still the most popular, but there are no significant changes in the table.

Tool	2019	2016	Trend
EXCEL	1	1	0
WIKI	2	3	1
RANCID	3	2	-1
RACKTABLES	4	6	2
IMS	5	4	-1
IRR	6	5	-1

Table 18. Trends in Inventory Management Tools

Table 19 lists other tools not pre-defined in the survey. Jira and Netbox are mentioned more than once. The table also shows that there is a wide variety of in-house developed solutions for Inventory Management.

Other tools:	• Jira (3) (one mentions addon Insight) • Netbox(2) • AirManager Otrs-cmdb • Ansible-Inventory • CMDB • Combodo itop • EMMA • GLPI • Netdot • Omnivista • OpenDCIM • Oxidized • PhpIPAM • ProactivaNet
In-house developed solutions:	• Automator (one module is inventory management) • Custom perl web software • DFN GIS • Equipment inventory • GARR database • In-house CMDB IIR • KIND • Ofbiz developed tool • PHP Development • Skladišče (inventory of devices) • Web interface to store data in Oracle DB

	• Xixare

Table 19. Other tools and in-house developed solutions for Inventory Management

4.10. Communication, Coordination and Chat

This section includes both software tools and communication methods like landlines or mobile phones, as they are also considered relevant tools for Communication, Coordination and Chat by the NOCs.

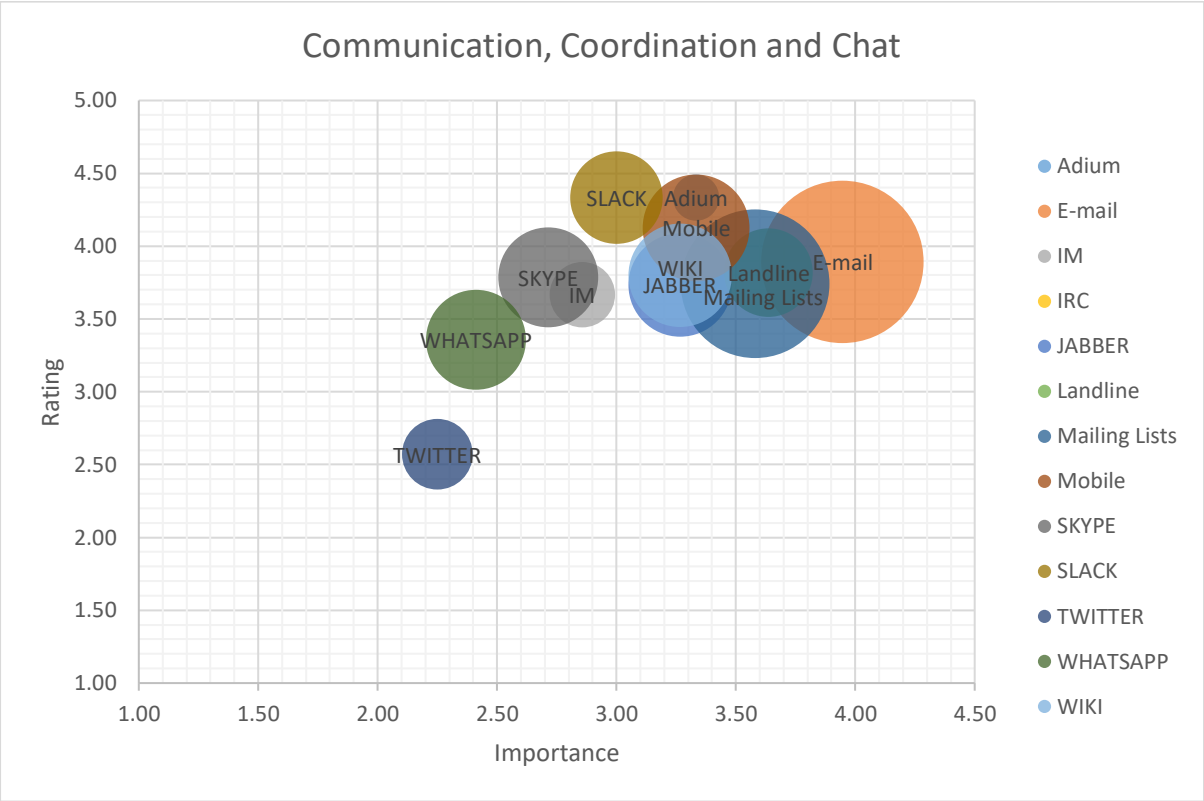

Chart 14. Software tools used for Communication, Coordination and Chat

Traditional communication methods like E-mail or Mailing lists are still the most popular and important among NOCs. Landlines are also important, but less used than mobile. Communication applications like Slack or Adium get better rating from the users than the traditional methods. Social networks like Whatsapp or Twitter also appear in the graph, although their usage is still low compared to other mechanisms.

Table 20 shows the trends in the number of NOC that use the Top-10 tools for Communication, Coordination and Chat tools and mechanisms, comparing the position they occupy in the responses

count table (sorting by number of responses for each tool). E-mail and Mailing lists still occupy the first 2 positions. In general, the use of new instant messaging tools has increased.

Tool	2019	2016	Trend
E-mail	1	1	0
Mailing Lists	2	2	0
Mobile	3	5	2
JABBER	4	6	2
WIKI	5	3	-2
SKYPE	6	4	-2
WHATSAPP	7	10	3
SLACK	8	12	4
Landline	9	9	0
TWITTER	10	8	-2

Table 20. Trends in Communication, Coordination and Chat Tools

Table 21 lists other Communication, Coordination and Chat tools that were not pre-defined in the survey. According to the responses, there are no in-house developed solutions for Communication, Coordination and Chat.

Other tools:	• Connectme • Mattermost • Nextcloud Chat • Riot-im • Rocket.Chat • ServiceNow • Telegram • Threema • Trello • Onlyoffice • Videoconferencing (Polycom)

Table 21. Other tools for Communication, Coordination and Chat

4.11. Out-of-band Access

The section about Out-of-band access did not contain any questions about the tools, as they were mostly hardware-based tools. On the other hand, NOCs considered it relevant to have information about how many NOCs felt responsible for this function. 75% of the NOCs that answered the question considered they were responsible for Out-of-band access management.

4.12. Resources Management

Chart 15 shows the software tools that NOCs use for Knowledge Management and Documentation

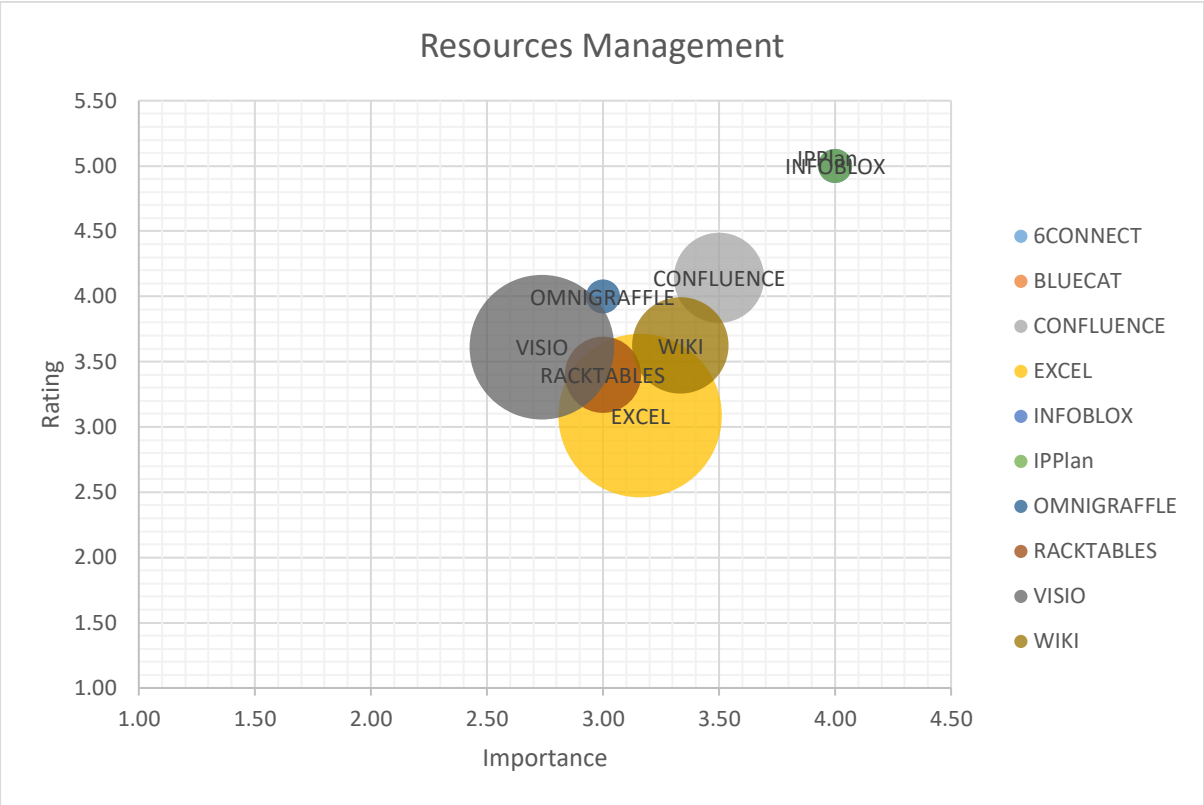

Chart 15. Software tools used for Resources Management

As in the case of Inventory Management, Excel is the most popular tool, although there are other tools that are more important or better for the NOCs. Other tools are much better valued or more important for the NOCs, but they are used by a significantly lower number of institutions.

Table 22 shows the trends in the number of NOC that use the tools for Resources Management, comparing the position they occupy in the responses count table (sorting by number of responses for each tool). Excel and Visio have exchanged positions, compared to 2016.

Tool	2019	2016	Trend
EXCEL	1	2	1
VISIO	2	1	-1
WIKI	3	3	0
CONFLUENCE	4	5	1
RACKTABLES	5	4	-1
INFOBLOX	6	9	3
IPPlan	7	8	1
OMNIGRAFFLE	8	7	-1
6CONNECT	9	6	-3
BLUECAT	10	10	0

Table 22. Trends in Resources Management Tools

Table 23 lists other tools and in-house developed solutions that were not pre-defined in the survey. PhpIPAM is mentioned three times.

Other tools:	• PhpIPAM (3) • EfficientIP SOLIDServer • IXP-manager • Microsoft IPAM • Netbox • Netdot • Nocproject.org • PowerPoint • ProactivaNet
In-house developed solutions:	• Custom perl web software • DFN GIS • Equipment inventory • GESIP • Homegrown database for IP-addresses • Igor • In-house CMDB • Internal IPam • IP Adress Management (IPAM) • IPIS (tracks IP assignments and syncs to RIPE DB) • Perl scripts • PHP Development

	• Web-based list of networks and router-interfaces • Web developed APP • Web interface to Oracle DB • Webform which is fed by a script that makes SNMP based routing table polls and DNS queries.

Table 23. Other tools and in-house developed solutions for Resources Management

4.13. Change Management

The survey included questions for five Change Management software tools. The results are shown in *Chart 16*.

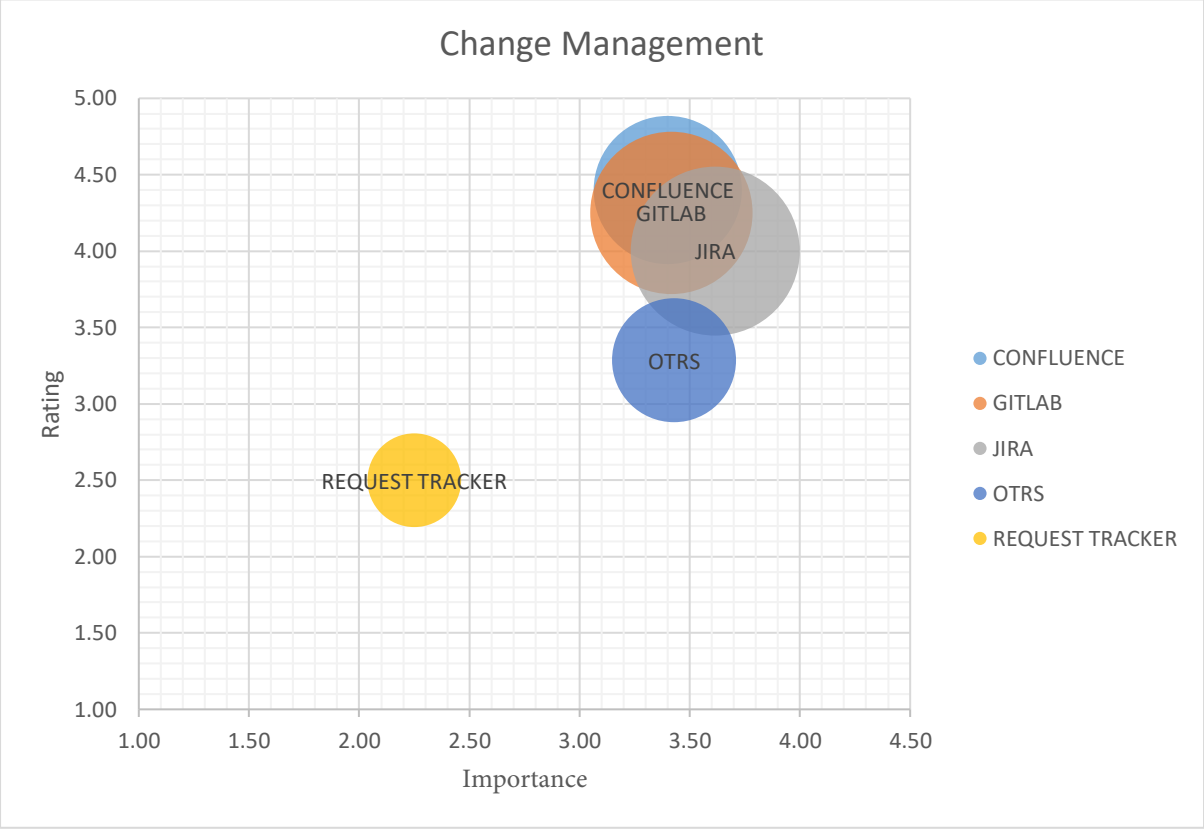

Chart 16. Software tools used for Change Management

Jira, Gitlab and Confluence have a similar level of adoption, importance and rating.

Table 24 shows the trends in the number of NOC that use the tools for Change Management, comparing the position they occupy in the responses count table (sorting by number of responses for

each tool). Gitlab is the tool that has escalated more positions according to the number of users and Request tracker has much less users than in the 2016 results.

Tool	2019	2016	Trend
JIRA	1	3	2
GITLAB	2	5	3
CONFLUENCE	3	4	1
OTRS	4	2	-2
REQUEST TRAC	5	1	-4

Table 24. Trends in Change Management Tools

Table 25 lists other tools and in-house developed solutions that were not pre-defined in the survey for Change Management. ServiceNow is mentioned twice.

Other tools:	• ServiceNow(2) • Combodo itop • Git • MeisterTask, • ProactivaNet • RANCID • Trello
In-house developed solutions:	• Change tracker • Storing configuration history • DFN GIS • In-house 'planned maintenance calendar' web app

Table 25. Other tools and in-house developed solutions for Change management

4.14. DDoS Mitigation

Several questions were asked regarding DDoS Mitigation solutions. The first one was about the mechanisms used for detection, the second one about the mechanisms used for mitigation and the third one about the tools. *Chart 17* shows the results for detection mechanisms.

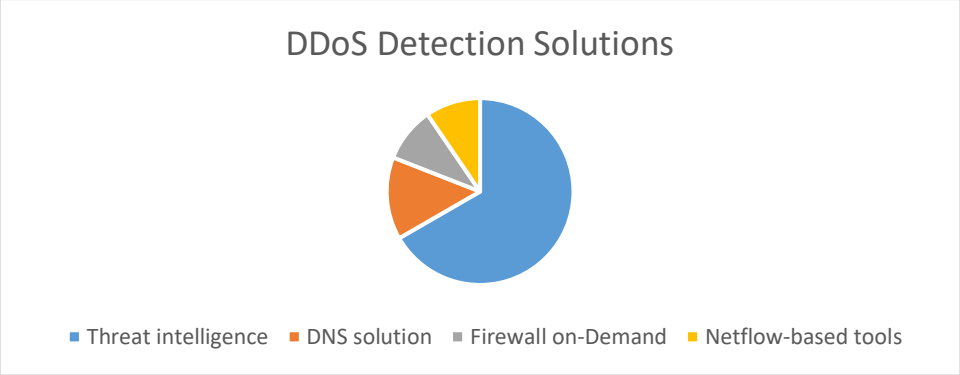

Chart 17. DDoS Detection Mechanisms

Threat intelligence is the most popular DDoS detection mechanism among NOCs.

Chart 18 shows the DDoS mitigation solutions.

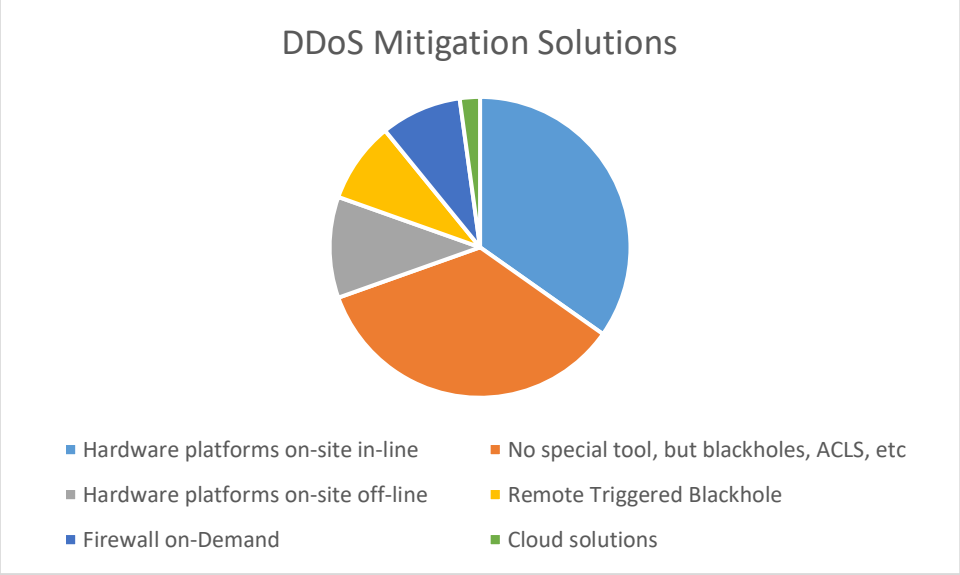

Chart 18. DDoS Mitigation Mechanisms

The number of institutions that use hardware in-line platforms equals the number of institutions that do not use special tools, but blackholes, ACLs, etc.

Table 26 lists other mechanisms for detection and mitigation that were not pre-defined in the survey, although some of them are in fact the tools that were asked for in the next question. As mechanisms, Remote-Triggered Blackholes (RTBH) seem quite popular according to the responses.

Other tools (detection)	• Arbor (3) (Peakflow SP) • Fastnetmon (2) • FoD (2)

	• DDoS mitigation • DFN Nemo • Firewall • Kentik • Minemel Netflow • Netflow based scripts • Radware Riorey • Syslog
Other tools (mitigation):	• FoD (4) • RTBH (4) • DFN Nada • Fortinet 1500D • Minemeld

Table 26. Detection and Mitigation mechanisms for DDoS mitigations

Chart19 shows the responses for the mitigation tools.

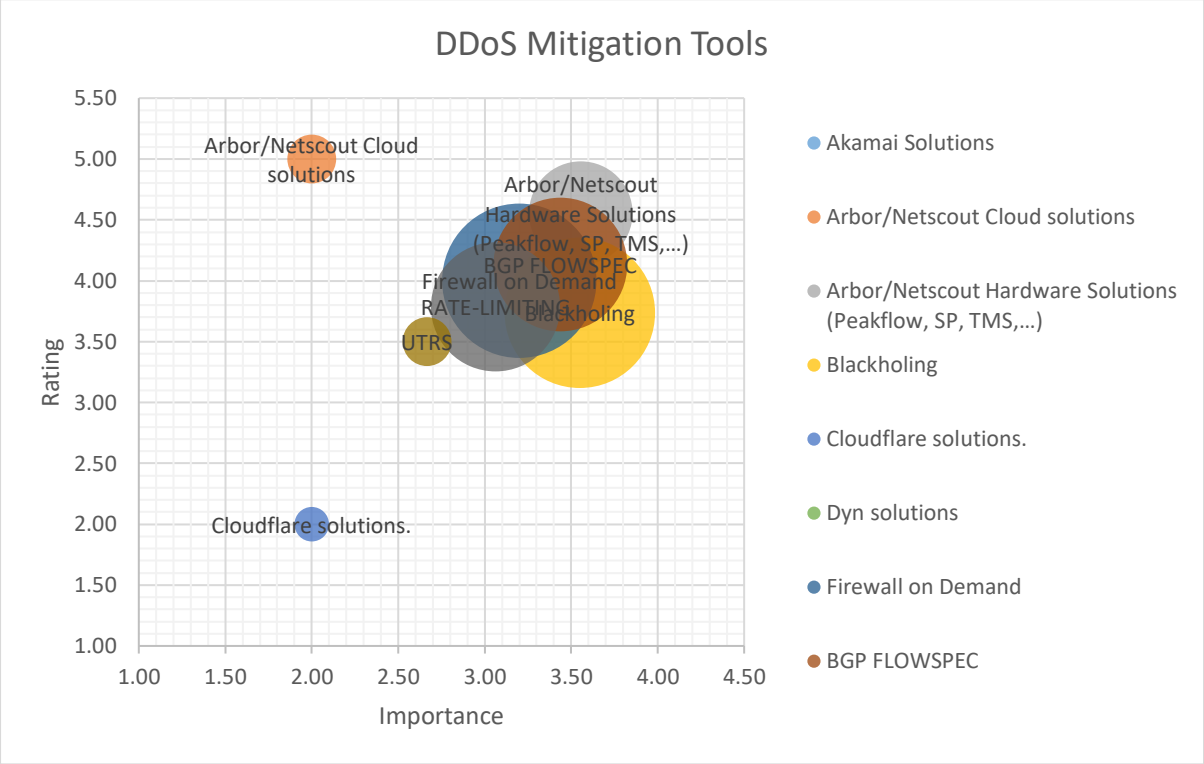

Chart 19. DDoS Mitigation Tools

The most popular tool is GÉANT's Firewall-on-demand (FoD), although Arbor hardware solutions and BGP Flowspec have better ratings for importance and rate. Cloud solutions are not very popular.

Table 27 shows the tools and their usage ranking over the three-year period for DDoS Mitigation.

Tool	2019	2016	Trend
Firewall on Demand	1	4	3
Blackholing	2	2	0
BGP FLOWSPEC	3	5	2
RATE-LIMITING	4	3	-1
Arbor/Netscout Hardware Solutions (Peakflow, SP, TMS,…)	5	6	1
Arbor/Netscout Cloud solutions	6		NEW
UTRS	7	9	2
Cloudflare solutions	8		NEW
Akamai Solutions	9	8	-1
Dyn solutions	10		NEW

Table 27. Trends in DDoS Mitigation Tools

Table 28 lists other tools and in-house developed solutions that were not pre-defined in the survey.

Other tools:	• F5 BigIP • Next generation firewall • PaloAlto • Remote triggered black hole
In-house developed solutions:	• AutoBH DDoS Protector • Black Wall • DFN Mitigation platform Nemo+Nada • ExaFS • Tool based on RTBH

Table 28. Other tools and in-house developed solutions for DDoS Mitigation

4.15. Data Aggregation, Representation and Visualisation

NOCS were asked about the tools they use to aggregate live data from various tools and visualise them in a human readable way. The results are shown in *Chart 20*.

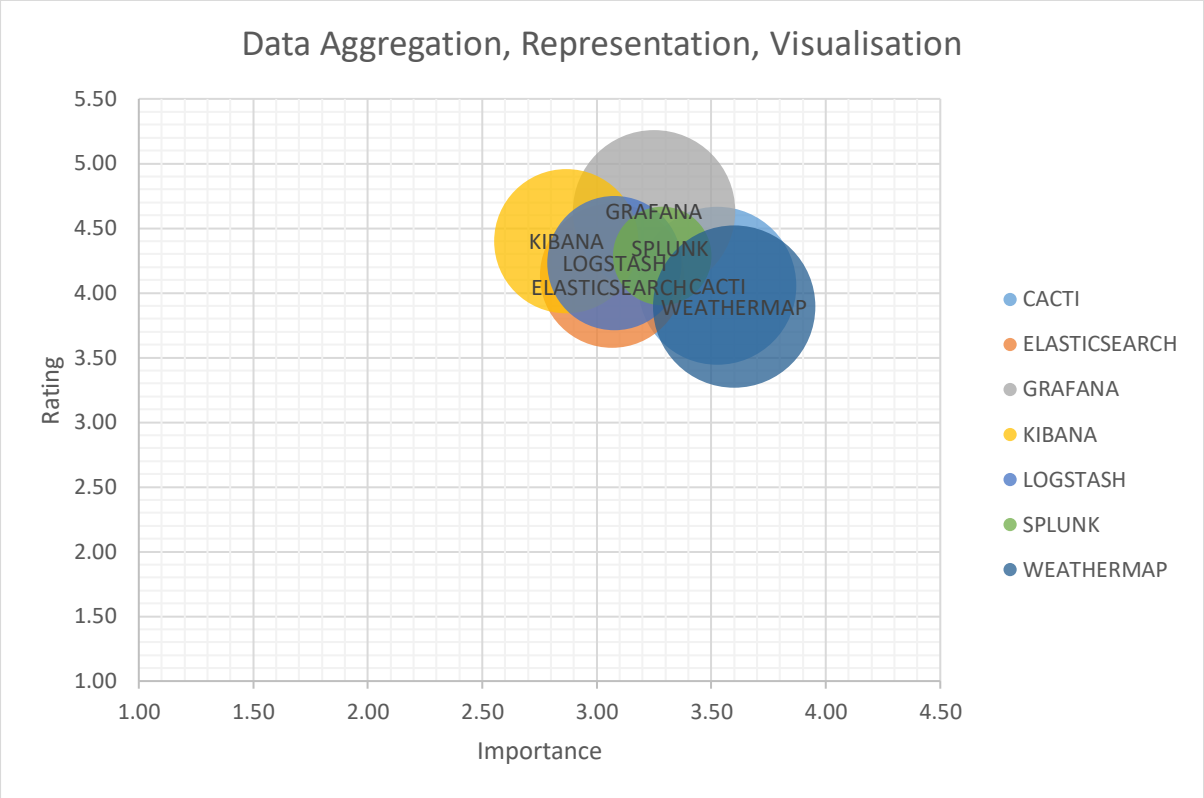

Chart 20. Software tools used for Data Aggregation, Representation and Visualisation

Several tools are quite popular and the importance and quality ratings for all of them are also high. If we compare to the 2016 results in *Table 29*, Grafana outstands in the first position, when it didn't appear in the results of the 2016 survey. All the other tools remain in the same position or lower in rank.

Tool	2019	2016	Trend
GRAFANA	1		NEW
WEATHERMAP	2	2	0
CACTI	3	1	-2
ELASTICSEARCH	4	3	-1
KIBANA	5	5	0
LOGSTASH	6	4	-2
SPLUNK	7	6	-1

Table 29. Trends in Data Aggregation, Representation and Visualisation Tools

Table 30 lists other tools and in-house developed solutions that were not pre-defined in the survey.

Other tools:	• Observium (2) • Cricket(2) • EMMA • Icinga • IXP-manager • Munin • Librenms • Prometheus • Zabbix
In-house developed solutions:	• DMON(under construction) • FTAS • G3 • GINS • In-house CMDB • Nemo • ServiceNow • SURFnet NetworkDashboard • TurboKrt

Table 30. Other tools and in-house developed solutions for data aggregation, representation and visualisation

4.16. Orchestration, Automation and Virtualisation

Several questions were asked regarding Orchestration, Automation and Virtualisation (OAV). The first one was about the kind of tasks that NOCs automate, the second one was about the number of devices with automation in the core, the third one concerned the number of devices with automation in the

access and the fourth one was about the tools. *Chart 21* shows the automated tasks and *Chart 22*, the median number of devices (not the average).

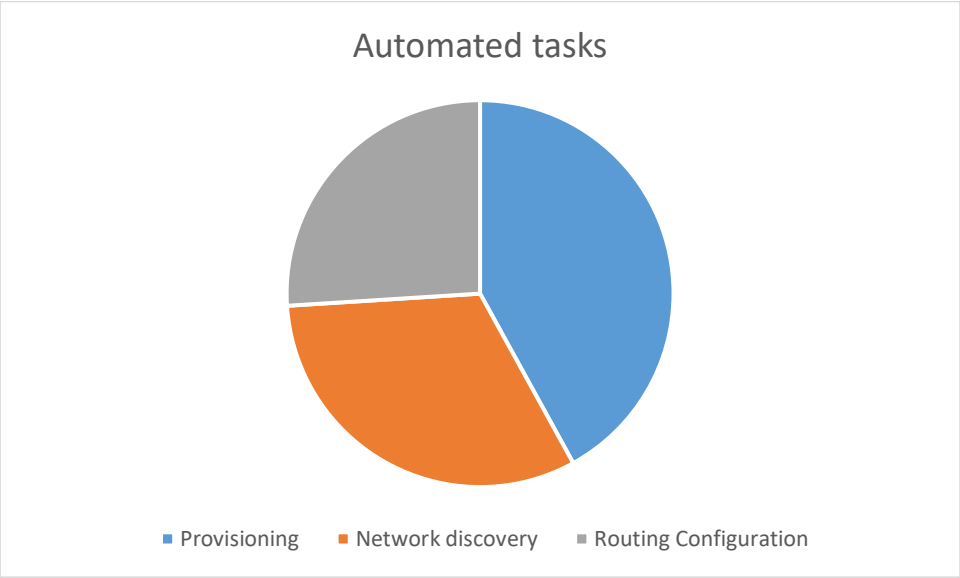

Chart 21. Automated Tasks

According to the results, the task that is more frequently automated by NOCs is provisioning, followed by network discovery and routing configuration. The number of devices where automation is used is smaller in the core than in the access (which is normal, because the core always has less devices than the access network).

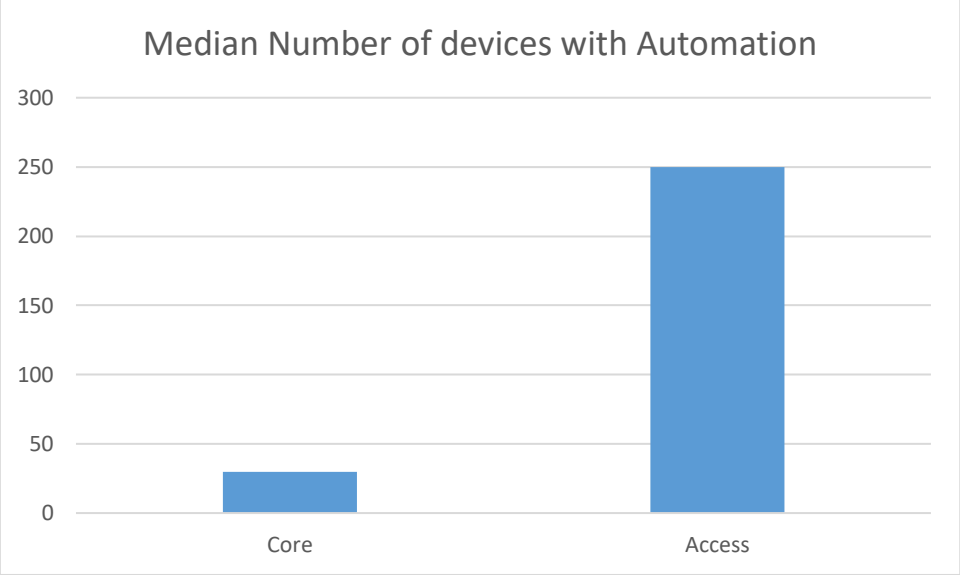

Chart 22. Median Number of Devices with Automation

Chart 23 shows the results for the tools and languages used for Orchestration, Automation and Virtualisation.

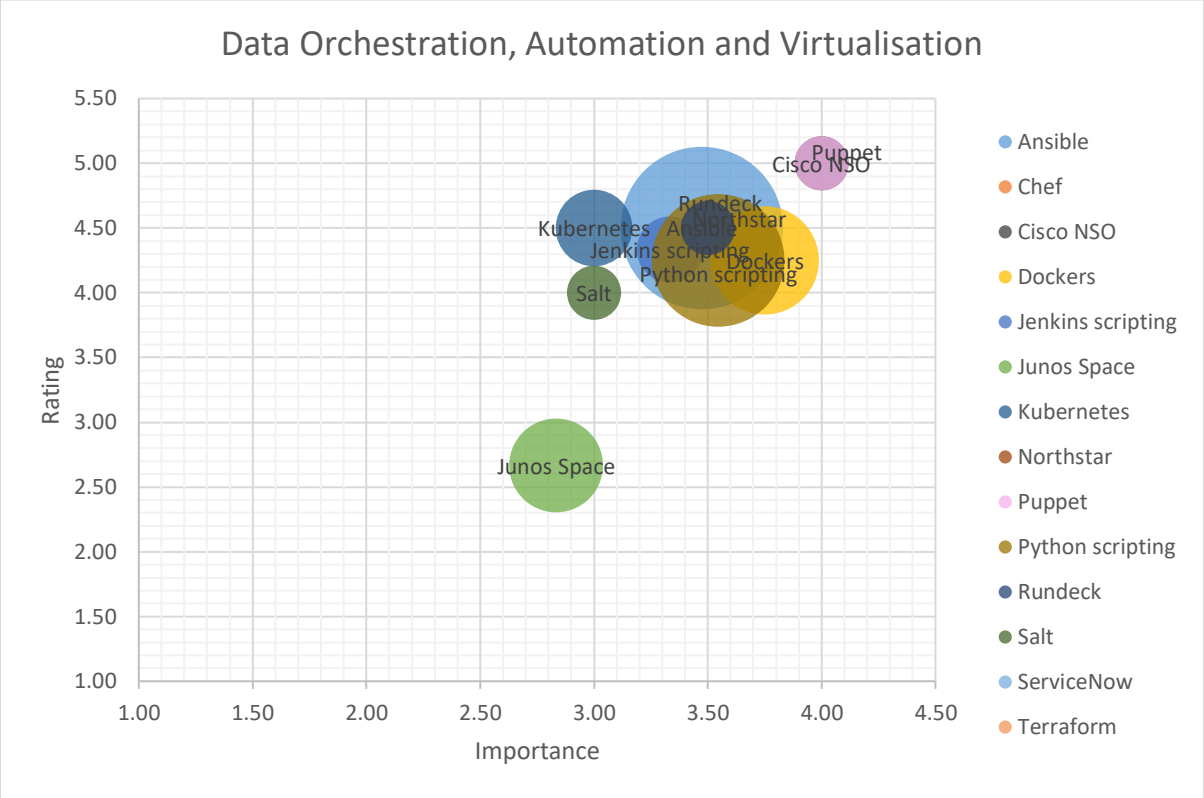

Chart 23. Software tools and languages used for Orchestration, Automation and Virtualisation

Ansible and Python are the most popular ways to automate tasks.

Table 31 lists other tools and in-house developed solutions that were not pre-defined in the survey. Scripting in different programming languages is mentioned.

Other tools:	• Bash scripts • Dude • EMMA • Perl • Zabbix
In-house developed solutions:	• Automator • Custom bash, expect and perl scripts • DFN GIS • Inventory monitor • MegaConf, AutoBH • Perl and javascripts scripts

	• Scripts to mass generate and deploy configuration and update related databases. • SURFnet WorkflowEngine

Table 31. Other tools and in-house developed solutions for Orchestration, Automation and Virtualisation

5. Standards and trainings

As part of the survey, SIG-NOC wanted to figure out the level of adoption of the various standards and industry best practice-based procedures and methodologies at NOCs.

Chart 24 shows the various standard adoptions.

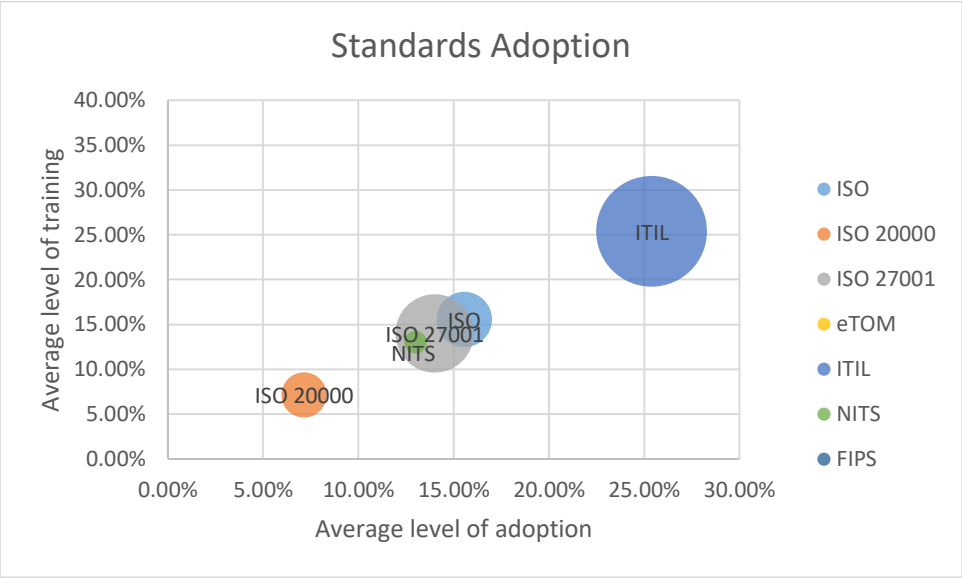

Chart 24: **Estimated level of adoption vs average of trained employees**

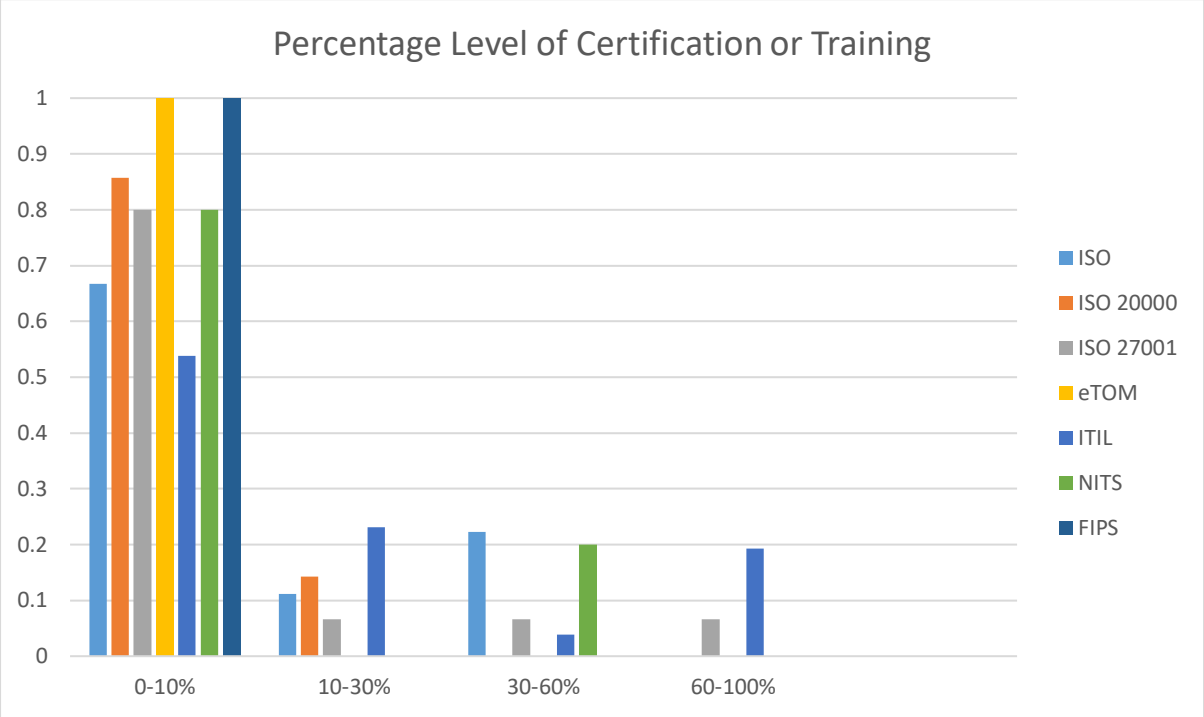

Chart 25. Percentage of Certified or Trained NOC Employees

Table 32 contains the answer to the open question "What technical training(s) are provided either in-house or contracted to your NOC personnel?"

General/Procedural trainings	• Mentoring inside organisation • ITIL Foundations for NOC technicians, ITIL Service Capability Modules (SOA, OSA, PPO, RCV) and Managing Through Lifecycle (MALC) (ITIL Expert certification) for NOC Manager. Cisco CCNA, Attendance to NOG Forums (Network Operators Group), Communication workshops. We include technical training in our tenders (about the equipment or the service we buy in the tender) • Mentoring top to bottom, technical courses of equipment vendors (Cisco, Juniper...), self-learning... • ITIL foundations to all involved staff members. • Trainings provided by vendors when a new equipment/software is deployed. • ISO awareness and risk management through Cyber security training • Network Working Group meetings at SWITCH Community. • Cisco Academy, Mikrotik Training, in-house training • Occasional trainings by vendors • In most cases, training courses in-house by the providers

Table 32. List of Training Opportunities that NOCs Provide to their Employees

6. Conclusions

Network Operation Centres are responsible for a broad range of functions and use a wide variety of tools to support them, according to the responses to the survey. In many cases, several tools are used for a single function, while some tools are used for more than one function. The number of in-house developed tools is also remarkable. This report explicitly does not attempt to draw any conclusions on which tools are the best. However, it should be helpful in determining which tools are most commonly used and therefore likely have a healthy community around them. It also illustrates situations where tools are widely used, but perhaps not as widely found to be useful or not so popular, but very useful for their users. While further conclusions are left to the reader; should this survey report raise any questions from you, then please engage with the SIG-NOC community [1] to find discussion and answers.

7. Acknowledgements

SIG-NOC acknowledges the contributions of all the organisations and their NOCs who participated in the survey and extends its special thanks to the SIG-NOC Steering Committee members: Tony Barber (GÉANT), Maria Isabel Gandía Carriedo (CSUC), Jonny Lundin (NORDUnet) and Ana Maria Medina (RedIRIS) and to the SIG-NOC coordinator, Magda Haver (GÉANT).

8. References

[1] GÉANT SIG-NOC home page https://wiki.geant.org/display/SIGNOC/

[2] NOC Survey 2012 https://www.terena.org/activities/tf-noc/survey.html

[3] SIG-NOC Survey 2016: https://wiki.geant.org/display/SIGNOC/SIG-NOC+Tools+Survey+2016


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