Introduction to Network Monitoring & Management

Campus Network Design & Operations Workshop

UNIVERSITY OF OREGON

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NSRC
Network Startup Resource Center

Objectives

- Introduce Core Concepts & Terminology
  - Network Monitoring & Management
  - What & Why we Monitor
  - Baseline Performance
  - Network Attack Detection
  - What & Why we Manage
  - Network Monitoring & Management Tools
  - The NOC: Consolidating Systems

Network Monitoring & Management

Monitoring

- Check the status of a network

Management

- Processes for successfully operating a network

Monitoring Systems & Services

- Systems
  - Routers
  - Switches
  - Servers
- Services
  - DNS
  - HTTP
  - SMTP
  - …

Why do we Monitor?

- Are Systems and Services Reachable?
- Are they Available?
- What's their Utilisation?
- What's their Performance
  - Round-trip times, throughout
  - Faults and Outages
- Have they been Configured or Changed?
- Are they under Attack?

Why do we Monitor?

- Know when there are problems – before our customers!
- Track resource utilisation, and bill our customers
- To Deliver on Service Level Agreements (SLAs)
  - What does management expect?
  - What do customers expect?
  - What does the rest of the Internet expect?
- To prove we're delivering
  - What would Five Nines take? 99.999%
- To ensure we meet SLAs in the future
  - Is our network about to fail? Become congested?

Uptime Expectations

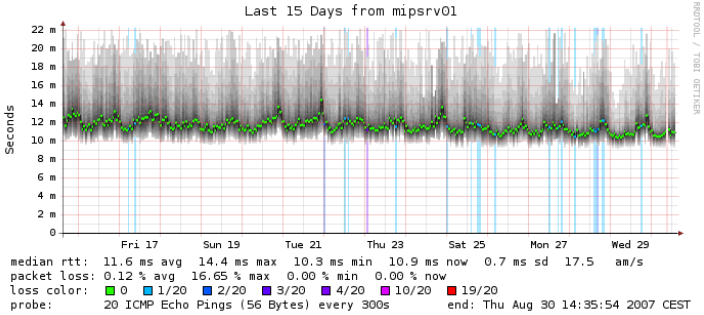
- What does it take to deliver 99.9% uptime?
  - Only 44 minutes of downtime a month!
- Need to shut down one hour a week?
  - 168 hours in week
  - That's only 99.4% uptime ((168-1)/168 = .99404762...)
- What does 99.999% uptime really mean?
  - 525960 (approx) minutes in a year
    - 99.999% uptime means 5 minutes and 15 seconds downtime!
    - For most of us this is just a fun exercise, not realistic.
- Maintenance might be negotiated in SLAs

Uptime Expectations

- What is meant by the network is “up”?
  - Does it work at every location?
  - Does it work at every host?
  - Is the network up if it works at the Boss’s desk?
  - Should the network be reachable from the Internet?
  - Does uptime include or exclude “Scheduled Maintenance”?

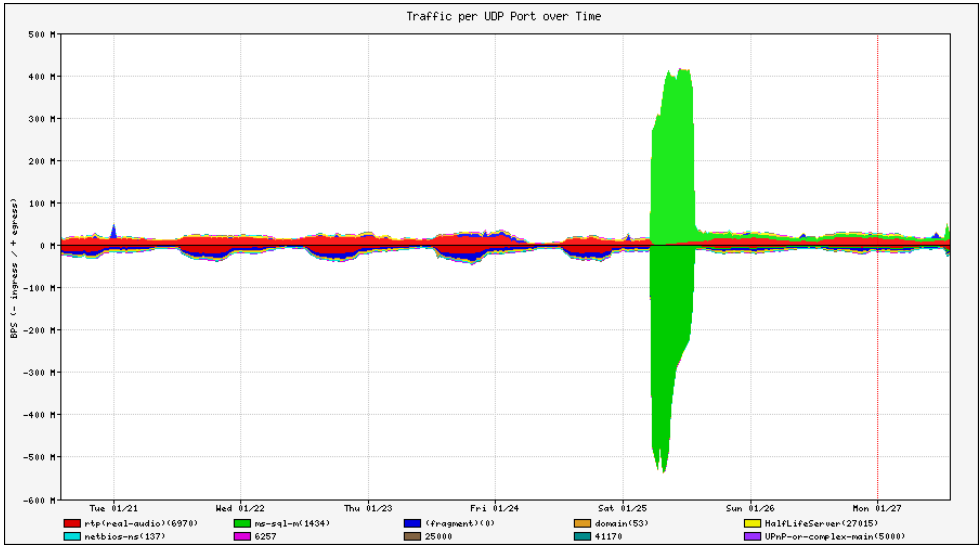
Establishing a Baseline

- **Monitoring** can be used to **Establish a Baseline**
- Baseline = What's normal for your network?
  - Typical latency across paths
  - Jitter across paths (shown in graph)
  - Load on links
  - Percent Resource Utilisation
  - Typical amounts of noise
    - Network scans & random attacks from the Internet
    - Dropped packets
    - Reported errors or failures



Detecting Attacks

- Deviation from baseline can mean an attack…
- Are there more flows than usual?
- Is the load higher on some servers or services?
  - CPU usage on border router?
- Have there been multiple service failures?



Any of these might mean attack

What do we Manage?

- Asset management: What equipment have we deployed?
  - What software is it running
  - What's its configuration (hardware & software)
  - Where is it installed
  - Do we have spares?
- Incident management: fault tracking and resolution
- Change management: Are we satisfying user requests?
  - Installing, moving, adding, or changing things
- Staff management

Why do we Manage?

- To ensure we meet business requirements for service level, incident response times, etc.
- To make efficient use of our resources (including staff)
- To learn from problems and make improvements to reduce future problems
- To plan for upgrades, and make purchasing decisions with sufficient lead time
- To help maintain a secure network

Key Network Management Tools

- Are some devices not responding or responding poorly, possibly because of a DoS attack or break-in?
  - Nagios
  - Smokeping
- Are you seeing unusual levels of traffic?
  - Cacti (SNMP)
  - LibreNMS (SNMP)
  - NfSen (NetFlow)

Network Traffic Analysis

- It is important to know what traverses your network
  - You learn about a new virus and find out that all infected machines connect to 128.129.130.131
  - Can you find out which machines have connected?
- Some tools that are available
  - Nfdump/NfSen, ntop-ng, Elastiflow, Akvorado: NetFlow
  - Snort, Suricata, Zeek: open source intrusion detection systems that are very useful to find viruses

Log Analysis

- Can be just as important as traffic analysis
- Central syslog server and gather logs from:
  - DHCP server, DNS servers, Mail servers, switches, routers, etc.
  - Now, you have data to look at
  - Given an IP, you can probably find user
- Lots of tools to correlate logs and alarm on critical events

NetFlow

- Routers can generate summary records about every traffic session seen
  - src addr, src port, dst addr, dst port, bytes/packets
- Software to record and analyze this data
  - e.g. Nfdump + NfSen, ntop-ng, Elastiflow, Akvorado
- Easily identify the top bandwidth users
- Drill down to find out what they were doing

Beware: Network Flows and NAT

- You need to see the real (internal) source IP addresses, not the shared external address
- If you are doing NAT on the border router that's not a problem
  - Generate Network flows on the interface before the NAT translation
- If you are doing NAT on a firewall then you need to generate Network flow data from the firewall, or from some device behind the firewall

Anomalous Traffic

- Intrusion Detection Systems (e.g. Snort, Suricata, Zeek) can identify suspicious traffic patterns, e.g.
  - machines using Bittorrent
  - machines infected with certain viruses/worms
  - some network-based attacks
- Typically connect IDS to a mirror port
- Risk of false positives, need to tune the rules
- Starting point for further investigation

Associating IP address to user

- ARP/DHCP logs map IP to MAC address
- Bridge tables map MAC address to switch port
  - Several tools can do this, e.g. Netdisco, LibreNMS
- 802.1x/RADIUS logs for wireless users
- AD logs for domain logins to workstations
- Network Access Control
  - e.g. PacketFence, forces wired users to login

Using Net Management

- BAYU: “Be Aware You’re Uploading”
- Detect P2P like Bittorrent and automatically send a warning E-mail telling the user to check whether what they’re doing is legal
- Amazingly effective when people realize they’re being watched!
- Some users may not be aware they had Bittorrent installed, and will uninstall it
- University of Oregon did this and Bittorrent use is now virtually non-existent.

Other Network Management Tools

- Ticket Systems: RT (Request Tracker)
  - Manage provisioning & support
- Configuration Management: RANCID, Oxidized
  - Track network device configurations
- Network Documentation: Netbox, GLPI
  - Inventory, Location, Ownership of Network Assets

NET MANAGEMENT	NETFLOW / IPFIX / SFLOW	LOGS / SIEM	DOCUMENTATION
Cacti	ElastiFlow	Beats	diagrams.net
LibreNMS	Filebeat/Packetbeat	Elasticsearch	GLPI
Nagios/check_mk	NfSen	Fluentd/fluent-bit	InvenTree
Netdata	ntop-ng	Loki	IPplan
OpenNMS	Akvorado	OSSEC/Wazuh	Netbox
Prometheus	**SECURITY / NIDS**	Sagan	Netdisco
Sensu	Nessus	**TICKETING**	phpIPAM
Zabbix	Prelude	OSticket	Snipe-IT
PERFORMANCE	Snort	OTRS	**CHANGE MGMT**
perfSONAR	Suricata	RT	Oxidized
Smokeping	Zeek	Trac	RANCID

What about newer tools ("NMM 2.0")?

- Older tool characteristics:
  - Classic polling model
  - Coarse data collection (5 minute intervals typically)
  - Low disk space usage but inefficient usage of CPU and disk IOPS
- In current use includes:
  - Streaming telemetry
  - Push/Pull methodology and agent-based
  - Time series databases (large) often NoSQL based
- Common terminology you may have heard of:
  - ELK, TICK, Kafka, Prometheus Stacks
  - Grafana, InfluxDB, MongoDB
  - Beats, Elasticsearch, Elastiflow, fluentd, Kabana, etc…

NMM 2.0: Netdata

- https://github.com/netdata/netdata/wiki
- Real-time, fine-grained, detailed host monitoring.

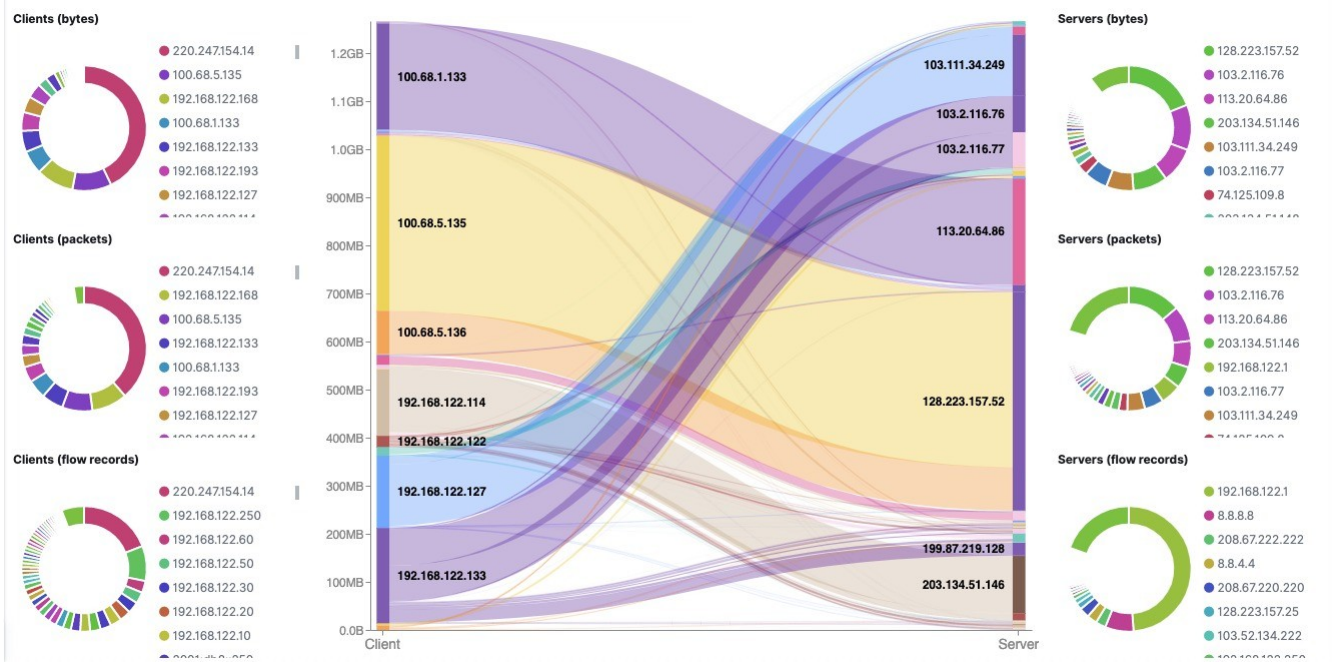
NMM 2.0: ElastiFlow

- Takes the following flow protocols
  - Netflow – IPFix – Sflow
  - Instead of NfSen
  - https://elastiflow.com *(commercial, limited free version available)*

logstash

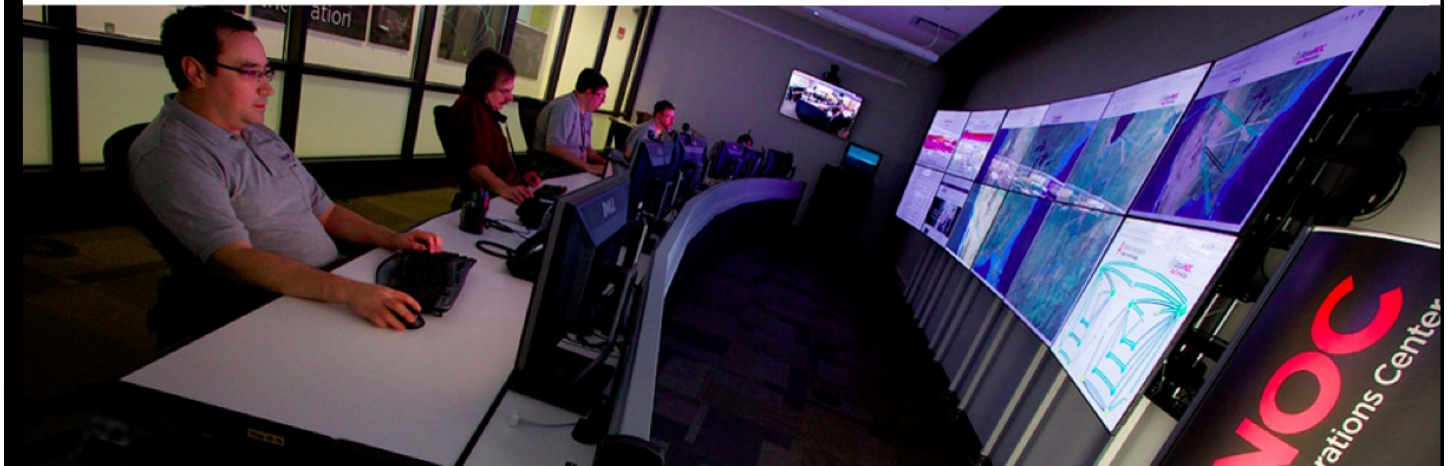
elasticsearch

kibana



NOC: Consolidating NMM Systems

- NOC = Network Operations Center
  - Coordination of tasks, handling of network related incidents (ticketing system)
  - Status of network and services (monitoring tools)
  - Where the tools are accessed
  - Store of Documentation (wiki, database, repository => network documentation tool(s))
- NOC Location
  - NOC is an organizational concept
  - Does not need to be a place, or even a single server
  - Remote / Distributed NOC is valid with OOB Management



NMM Review

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- Baseline Performance & Attack Detection
- Network Attack Detection
- What & Why we Manage
- Network Monitoring & Management Tools
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Questions?