

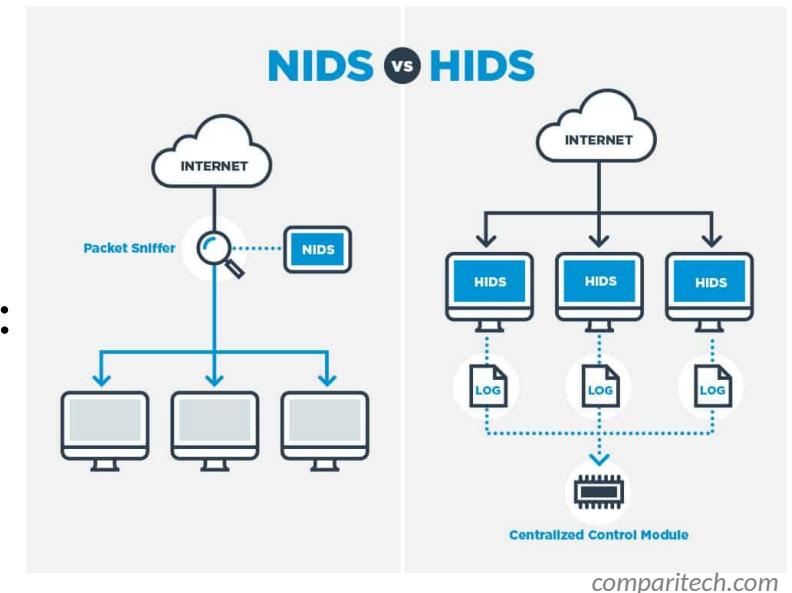
Network Traffic Analysis with **Malcolm**

A faint watermark of the Malcolm logo is visible behind the word "Malcolm". The logo consists of a stylized yellow 'M' shape with intricate internal patterns, centered over a grid of thin blue lines.

Seth Grover, Malcolm developer • Cybersecurity R&D • Idaho National Lab

Intrusion Detection Systems

- HIDS: Host Intrusion Detection Systems
 - Agents run on individual hosts or devices on a network
 - Not what we're talking about today
- NIDS: Network Intrusion Detection Systems
 - Monitor and analyze network traffic for anomalies: suspicious activity, policy violations, etc.
 - Generally passive/out-of-band; otherwise it's an Intrusion Prevention System
 - Detection methods
 - Signature-based detection
 - Statistical anomaly-based detection
 - Stateful protocol analysis detection



IDS: Types of Attacks

- Scanning Attack
 - Determine network topology
 - IDS highlights connections from one host to many other hosts in the network, or connection attempts to sequential IP addresses and/or ports
- Denial of Service Attack
 - Interrupt service by flooding requests or flaws in protocol implementations
 - IDS identifies large volume of traffic from or to a particular host or invalid connection states (e.g., TCP SYN/ACK with no ACK)
- Penetration Attack
 - Gain access to system resources by exploiting a software or configuration flaw
 - Trickier, but IDS may detect vulnerable software versions or simply alert on unusual operations (e.g., a “write” operation in an already-configured environment with mostly “read” operations)





- Extensible, open-source passive network analysis framework
- More than just an Intrusion Detection System:
 - Packet capture (like TCPDUMP)
 - Traffic inspection (like Wireshark)
 - Intrusion detection (like SNORT)
 - Log recording (like NetFlow and syslog)
 - Scripting framework (like python™)



Strengths

- Analyzes both link-layer and application-layer behavior
- Content extraction
- Behavioral analysis
- Session correlation
- Can add support for uncommon protocols through scripts/plugins

Weaknesses

- Session metadata only (not full payload)
- Setup and configuration can be complicated
- Produces flat textual log files which can be unwieldy for in-depth analysis

Zeek Log Files

- Network Protocols
 - Files
 - Detection
 - Network Observations

conn.log IP, TCP, UDP, ICMP connection details		
FIELD	TYPE	DESCRIPTION
to	time	Timestamp of the first packet
uid	string	Unique ID of the connection
orig_ip_n	addr	Originating IP address string
orig_ip_p	port	Originating IP address PORT/UDP port for ICMP/ICMP
resp_ip_n	addr	Responding IP address string
resp_ip_p	port	Responding IP address PORT/UDP port for ICMP/ICMP
proto	proto	Transport layer protocol of connection
service	string	Selected application protocol, if any
duration	interval	Connection length
http_bytes	uint64	HTTP payload bytes from sequence numbers of HTTP
http_ipbytes	uint64	HTTP payload bytes from sequence numbers of HTTP
conn.state	string	Connection state (one of: <code>new, open, closed</code>)
local_ipn	addr	IP of the local host, netid
local_ipo	addr	IP of the remote host, netid
remote_ipn	addr	Number of bytes missing due to current gap
history	string	Connection state history (one of: <code>new, open, closed</code>)
orig_pkts	uint64	Number of Orig packets
orig_ip_pkts	uint64	Number of Orig IP packets
orig_ip_pkts_hex	uint64	Number of Orig IP packets (in hex format, length 16)
resp_pkts	uint64	Number of Resp packets
resp_ip_pkts	uint64	Number of Resp IP packets
resp_ip_pkts_hex	uint64	Number of Resp IP packets (in hex format, length 16)
closed_pkts	int	If <code>closed</code> , connection ID of the last closing connection
orig_ip_addr	string	Low layer address of the originator
resp_ip_addr	string	Low layer address of the responder
site	int	The user ID/AS for this connection
inet_ifids	int	The inner IFIDs for this connection

http.log HTTP request/reply details		
FIELD	TYPE	DESCRIPTION
to	time	Timestamp of the HTTP request
req_id_n	int	Underlying connection info - See conn.log
trans_depth	uint64	Protocol depth into the connection
method	string	HTTP Request verb (GET, POST, etc.)
host	string	Name of the host header
uri	string	URI used in this request
referer	string	Value of the "Referer" header
user_agent	string	Value of the User-Agent header
response_body_hex	uint64	Uncompressed content size of the data
response_body_hex	uint64	Uncompressed content size of the data
status_code	uint64	Status code returned by the server
status_msg	string	Status message returned by the server
info_code	uint64	Last error from resp.reply.message by server
info_msg	string	Last error from resp.reply.message by server
tags	set	Indicators of various attributes discovered
lastheader	string	Timestamp of last header is performed
password	string	Timestamp of user-name is performed
process	set	Headers initiation of a process-request
orig_host	vector	The unique Origin-Host
orig_header	vector	The unique Origin-Header
orig_name_type	vector	The type-From-Drag
resp_header	vector	The unique Destination-Header
resp_headers	vector	The names-From-Drag
resp_name_type	vector	The type-From-Reply
client_header_hex	vector	The names of HTTP headers sent by client
server_header_hex	vector	The names of HTTP headers sent by host
cookie_hex	vector	Variable names extracted from cookie
cf_cookie	vector	Variable names extracted from the URL
cf_queryparams	vector	HTTP Header parameters as needed
cf_queryvars	vector	HTTP query-parameters and sections as needed

files.log File analysis results		
FIELD	TYPE	DESCRIPTION
id	int	Resource identifier for each resource
file	string	Unique identifier for average file
is_header	bool	Boolean that indicated if the data
is_header	bool	Boolean that indicated if the data
content_size	int	Content size (in bytes) for which the transferred
resource	string	Unique identifier of the resource of the file data.
depth	count	Depth of the related resource
analysis_id	int	ID of the element which is performing the analysis
storage_type	string	The type of storage containing the file's signatures
filename	string	Filename, Extension, and file type
duration	interval	The duration that the file was analyzed
local_path	bool	Did the file originate locally?
is_dir	bool	Was the file a directory or a file?
used_space	float	Number of bytes consumed by the analysis engine
total_space	float	Total number of bytes that should comprise the file
missing_bytes	float	Number of bytes in the file missing, if any
overflows_bytes	float	Out-of-bounds bytes in the stream due to overflow
streamed	bool	If the file analysis timed out at their source
parent_file	string	Container of the ID this was extracted from
modified	string	MD5Hash hash of the file
extracted	string	Local filename of download files, if any exist
entropy	double	Information density of the file contents

FIELD	TYPE	DESCRIPTION
pe	None	Current executable.
pe_b	String	The base name of the file used to create the PE executable.
machine	String	The target machine that the PE was created for.
compile_dt	None	The date that the PE was created at.
os	String	The required operating system.
subprocess	String	The application that it is required to run via.
is_32bit	Bool	Is the PE 32 bit executable, or just an executable?
is_64bit	Bool	Is the PE 64 bit executable?
has_x86	Bool	Does the PE support Intel based x86 architecture?
has_x64	Bool	Does the PE support AMD based x64 architecture?
has_i386	Bool	Does the PE have an i386 image by memory?
has_i686	Bool	Does the PE have an i686 image by memory?
has_i860	Bool	Does the PE have an i860 image by memory?
has_m68k	Bool	Does the PE have an m68k image by memory?
has_m88k	Bool	Does the PE have an m88k image by memory?
has_msp430	Bool	Does the PE have an msp430 image by memory?
has_sh3	Bool	Does the PE have a sh3 image by memory?
has_sh4	Bool	Does the PE have a sh4 image by memory?
has_v850	Bool	Does the PE have a v850 image by memory?
has_w32	Bool	Does the PE have a w32 image by memory?
has_w64	Bool	Does the PE have a w64 image by memory?
section_names	String	The names of the sections, in order.

corelight.com

Network Protocols

- conn - Network session tracking
 - Identified by session 4-tuple (originating IP:port, responding IP:port)
 - One session (line in a log file) for every IP connection
 - Unique identifier (UID) ties lines from other logs to a session
- http , modbus , ftp , dns, etc.
 - Protocol-specific log files created as traffic is seen
 - Contain application-layer metadata about network activities

Files

- files - File analysis results
 - Each transferred file identified with FUID
 - Associated with connection UID(s) over which file was transferred
 - File name, mime type, file size, etc. provided when available
- pe - Analysis of Portable Executable (PE) files
 - Target platform, architecture, OS, etc. for executables transferred across the network
- x509 - Analysis of X.509 public key certificates

Detection

- notice - Zeek concept of “alarms,” notices draw extra attention to an event
 - Conn::Content_Gap, DNS::External_Name, FTP::Bruteforcing, Heartbleed::SSL_Heartbeat_Attack, HTTP::SQL_Injection_Attacker, Scan::Address_Scan, Scan::Port_Scan, Software::Vulnerable_Version, SSH::Password_Guessing, SSL::Certificate_Expired, Weird::Activity, ...
 - <https://docs.zeek.org/en/stable/zeek-noticeindex.html>

Detection (cont.)

- weird - Unexpected network-level activity
 - > 150 weirdness indicators across many protocols
 - <https://docs.zeek.org/en/stable/scripts/base/frameworks/notice/weird.zeek.html#id1>
- signatures - Signature matches, including hits from enabled carved file scanners like ClamAV, YARA and capa

Network Observations

- Periodic dump of entities seen over the last day
 - known_certs - SSL certificates
 - known_devices - MAC addresses
 - known_hosts - Hosts with TCP handshakes
 - known_modbus - Modbus masters and slaves
 - known_services - Services (TCP “servers”)
 - software - Software being used on the network (e.g., Apache, OpenSSH, etc.)
 - Could be used for identifying vulnerable versions of software or firmware



Arkime

Strengths

- Large scale index packet capture and search tool
- Packet analysis engine with support for many common IT protocols
- Web interface for browsing, searching, analysis and PCAP carving for exporting
- PCAP payloads (not just session header/metadata) are viewable and searchable

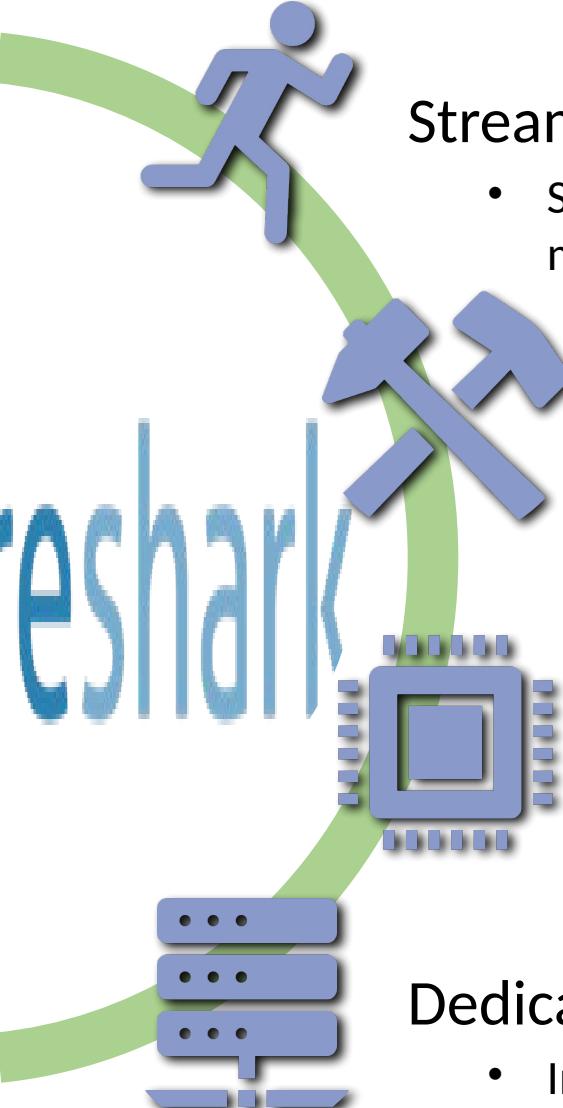
Weaknesses

- No OT protocol support
- Adding new protocol parsers requires C programming



A powerful open-source network traffic analysis tool suite.

<https://github.com/idaholab/Malcolm>



Streamlined deployment

- Suitable for field use (hunt or incident response) or SOC deployment. Runs in Docker on Linux, macOS and Windows platforms. Provides easy-to-use web-based user interfaces.

Industry-standard tools

- Uses Arkime and Zeek for network traffic capture, Logstash for parsing and enrichment, OpenSearch for indexing and Dashboards and Arkime Viewer for visualization. Also leverages OpenSearch Anomaly Detection, YARA, capa, ClamAV, CyberChef and other proven tools for analysis of traffic and artifacts.

Expanding control systems visibility

- Analyzes more protocols used in operational technology (OT) networks than other open-source or paid solutions. Ongoing development is focused on increasing the quantity and quality of industrial control systems (ICS) traffic.

Dedicated sensor appliance

- Includes Hedgehog Linux, a hardened Linux distribution for capturing network traffic and forwarding its metadata to Malcolm.

Malcolm



Components

<https://github.com/idaholab/Malcolm/#Components>



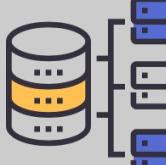
Capture



File Scanning



Forwarding & enrichment



Storage



zeek



Arkime



ClamAV®



beats



OpenSearch



Anomaly Detection



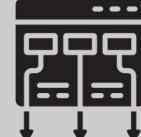
Alerting



Visualization



Payload Analysis



Framework



OpenSearch Dashboards



CyberChef



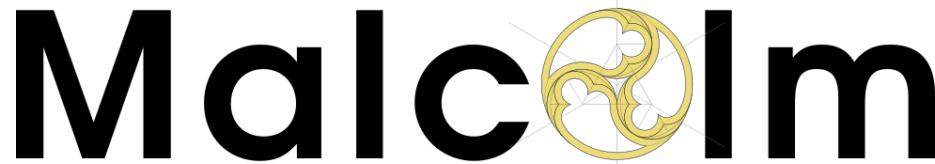
docker



Arkime session PCAP export to
WIRESHARK



NGINX



Internet layer
Border Gateway Protocol (BGP)
Building Automation and Control (BACnet)
Bristol Standard Asynchronous Protocol (BSAP)
Distributed Computing Environment / Remote Procedure Calls (DCE/RPC)
Dynamic Host Configuration Protocol (DHCP)
Distributed Network Protocol 3 (DNP3)
Domain Name System (DNS)
EtherCAT
EtherNet/IP / Common Industrial Protocol (CIP)
FTP (File Transfer Protocol)
Google Quick UDP Internet Connections (gQUIC)
Hypertext Transfer Protocol (HTTP)
IPsec
Internet Relay Chat (IRC)
Lightweight Directory Access Protocol (LDAP)
Kerberos
Modbus
MQ Telemetry Transport (MQTT)
MySQL
NT Lan Manager (NTLM)
Network Time Protocol (NTP)
Oracle

Supported Protocols

<https://github.com/idaholab/Malcolm/#Protocols>

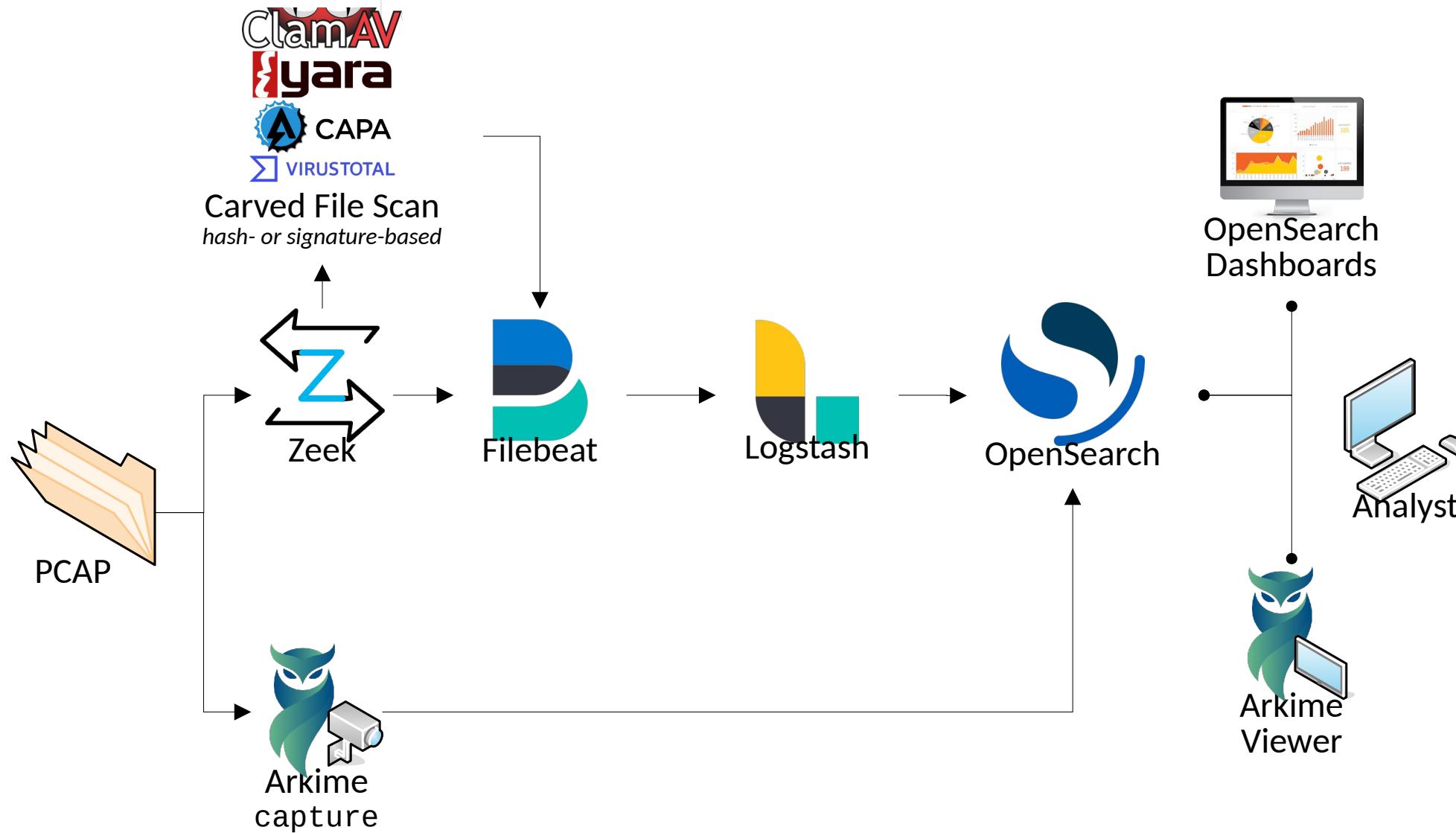
Open Shortest Path First (OSPF)
OpenVPN
PostgreSQL
Process Field Net (PROFINET)
Remote Authentication Dial-In User Service (RADIUS)
Remote Desktop Protocol (RDP)
Remote Framebuffer (RFB)
S7comm / Connection Oriented Transport Protocol (COTP)
Secure Shell (SSH)
Secure Sockets Layer (SSL) / Transport Layer Security (TLS)
Session Initiation Protocol (SIP)
Server Message Block (SMB) / Common Internet File System (CIFS)
Simple Mail Transfer Protocol (SMTP)
Simple Network Management Protocol (SNMP)
SOCKS
STUN (Session Traversal Utilities for NAT)
Syslog
Tabular Data Stream (TDS)
Telnet / remote shell (rsh) / remote login (rlogin)
TFTP (Trivial File Transfer Protocol)
WireGuard
various tunnel protocols (e.g., GTP, GRE, Teredo, AYIYA, IP-in-IP, etc.)

* Industrial control systems protocols indicated with **bold**

Malcolm

Data Pipeline

<https://github.com/idaholab/Malcolm>

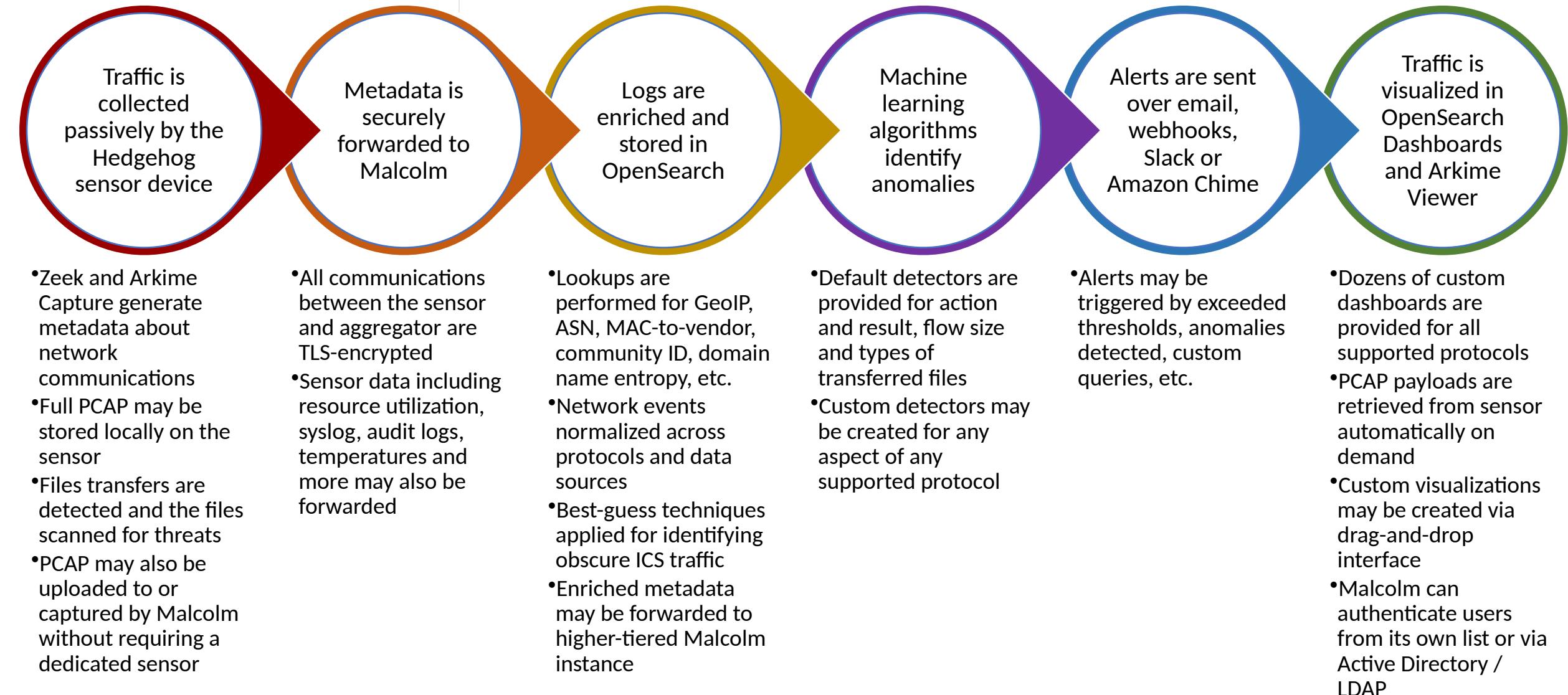


Malcolm



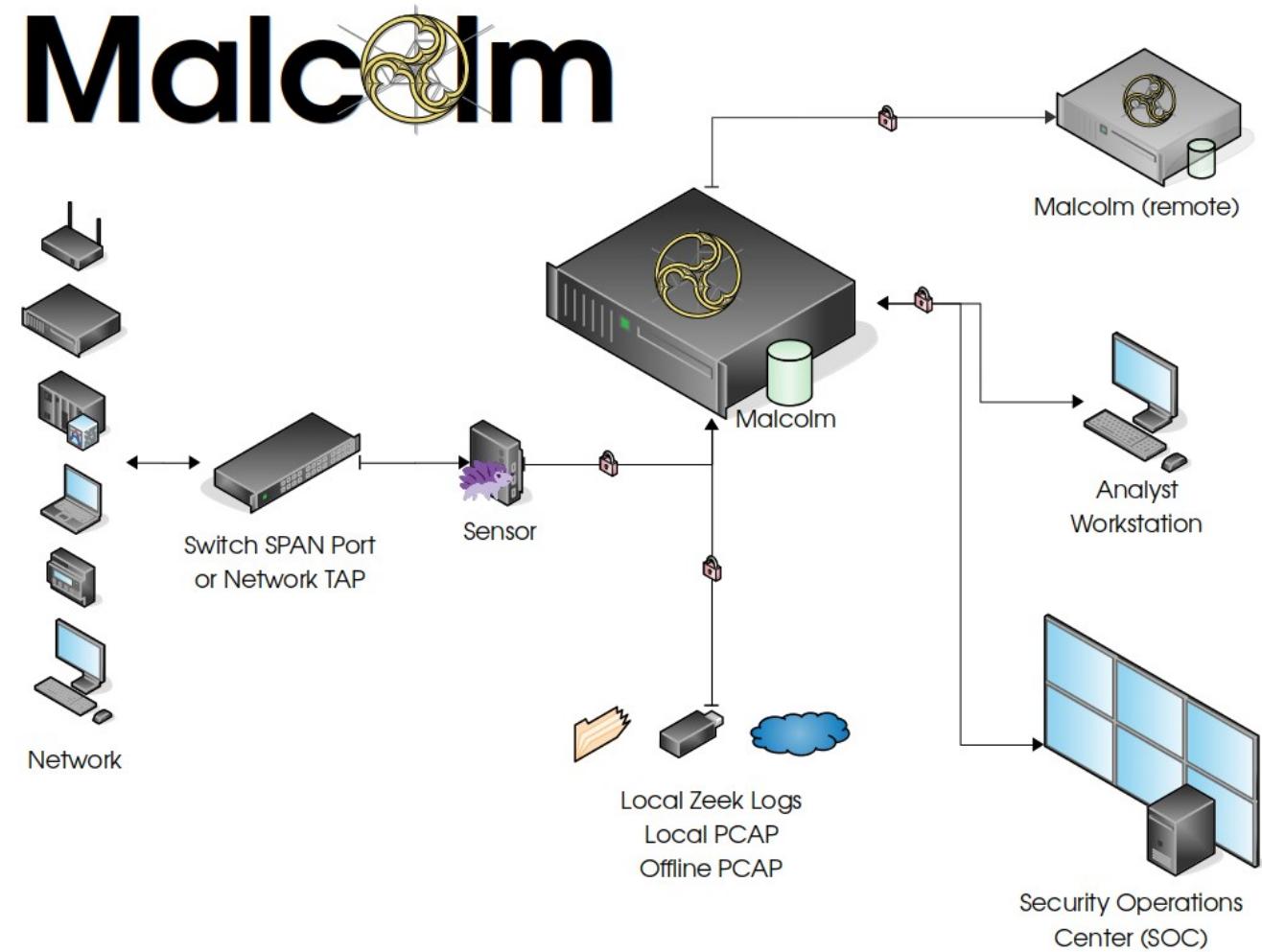
Data Pipeline

<https://github.com/idaholab/Malcolm>



Configuring and Running Malcolm

- Runs natively in Docker or in a Virtual Machine
- 16+GB RAM, 4+ cores, “enough” disk for PCAP and logs suggested
- Documentation and source code on GitHub:
github.com/idaholab/Malcolm
- Walkthroughs on [YouTube](#): search “Malcolm Network Traffic Analysis”



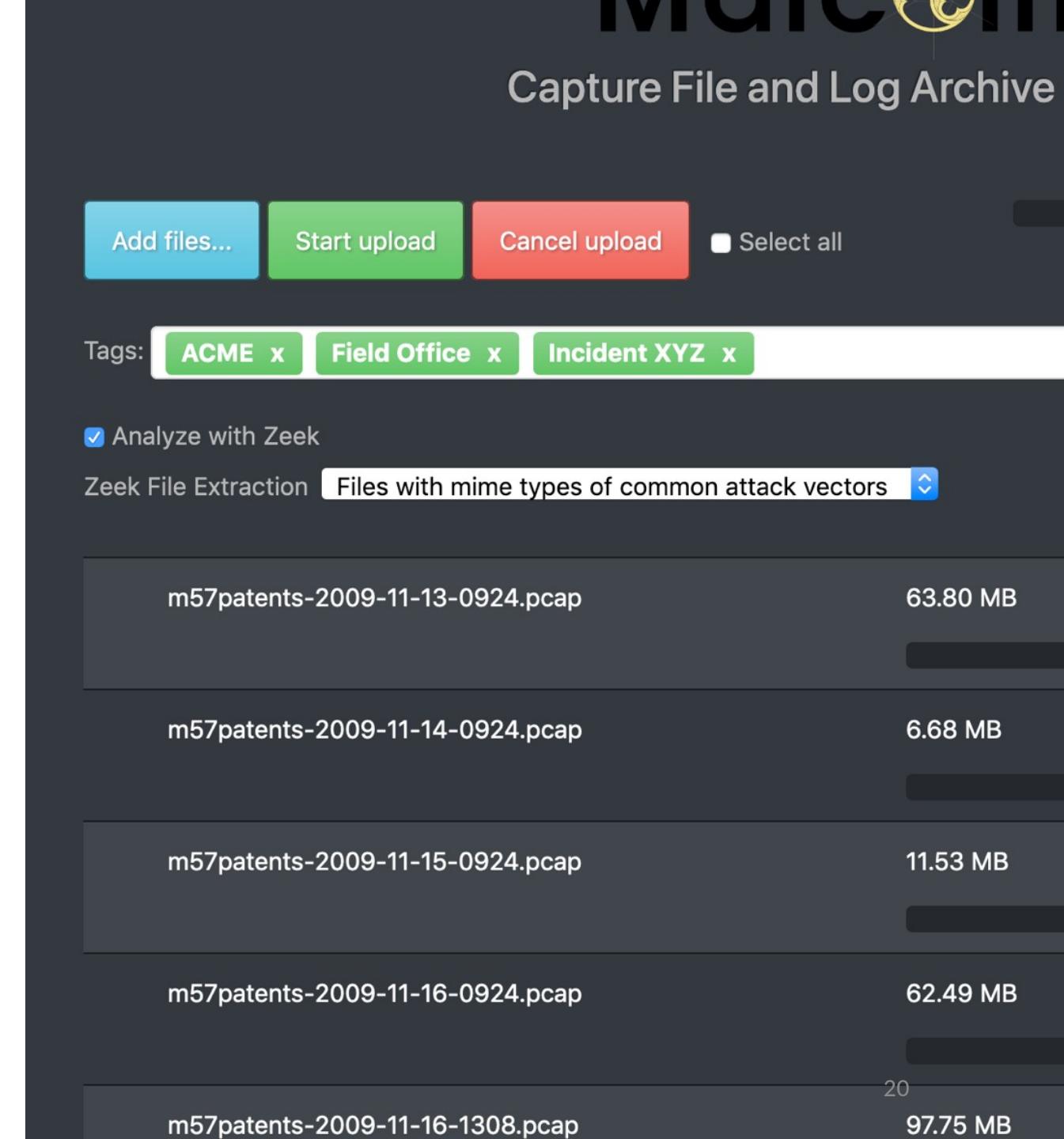
Identifying Network Hosts and Subnets

- Assign custom names to network hosts and subnets prior to PCAP import
- Allows identification of cross-segment traffic and name-based search and filter
- Define in text file(s) or via web interface
- <https://localhost/name-map-ui>

	Address	Name	Tag	Search mappings	
t	06:46:0b:a6:16:bf	serial-host.intranet.lan	testbed		
ent	10.0.0.0/8	corporate			
t	127.0.0.1	localhost			
t	127.0.1.1	localhost			
ent	172.16.0.0/12	virtualized	testbed		
t	192.168.10.10	office-laptop.intranet.lan			
ent	192.168.40.0/24	corporate			
ent	192.168.50.0/24	corporate			
ent	192.168.100.0/24	control			
ent	192.168.200.0/24	dmz			
t	::1	localhost			

Importing Traffic Captures for Analysis

- Specify tags for search and filter
- Enable Zeek analysis and file extraction
 - Or configure as global default
- Upload PCAP files or archived Zeek logs
 - pcapng not supported yet
- <https://localhost/upload>



Data Tagging and Enrichment



- Logstash enriches Zeek log data
 - MAC addresses to hardware vendor
 - GeoIP and ASN lookups
 - Internal/external traffic based on IP ranges
 - Reverse DNS lookups
 - DNS query and hostname entropy analysis
 - Connection fingerprinting (JA3 for TLS, HASSH for SSH, Community ID for flows)
- tags field
 - Populated for both Arkime sessions and Zeek logs with tags provided on upload and words extracted from PCAP filenames
 - `internal_source`,
`internal_destination`,
`external_source`,
`external_destination`,
`cross_segment`

OpenSearch Dashboards

- Front end for Zeek logs
- Prebuilt visualizations for all protocols Malcolm parses
- WYSIWYG editors to create custom visualizations and dashboards
- Drill down from high-level trends to specific items of interest
- <https://localhost/dashboards>

The screenshot shows the OpenSearch Dashboards interface with the 'Malcolm' dashboard selected. The top navigation bar includes 'Dashboard' and 'Security Overview'. The main content area is divided into several sections:

- Zeek Logs**: A sidebar with links to various log categories: General, Overview, Security Overview, ICS/IoT Security Overview, Severity, Connections, Actions and Results, Files, Executables, Software, Notices, Weird, Signatures, Intel Feeds, and Arkime.
- Common Protocols**: A list of network protocols: DCE/RPC, DHCP, DNS, FTP / TFTP, HTTP, IRC, Kerberos, LDAP, MQTT, MySQL, NTLM, NTP, OSPF, QUIC, RADIUS, RDP, RFB, SIP, SMB, SMTP, SNMP, SSH, SSL, X.509 Certificates, STUN, Syslog, TDS / TDS RPC / TDS SQL, Telnet / rlogin, rsh, and Tunnels.
- ICS/IoT Protocols**: A section listing Outdated/Insecure Application Protocols: Application Protocol (Protocol Version, Count). The data is as follows:

Application Protocol	Protocol Version	Count
ftp	-	1,063
smb	1	535
tftp	-	64
ntp	3	42
tls	TLSv10	38

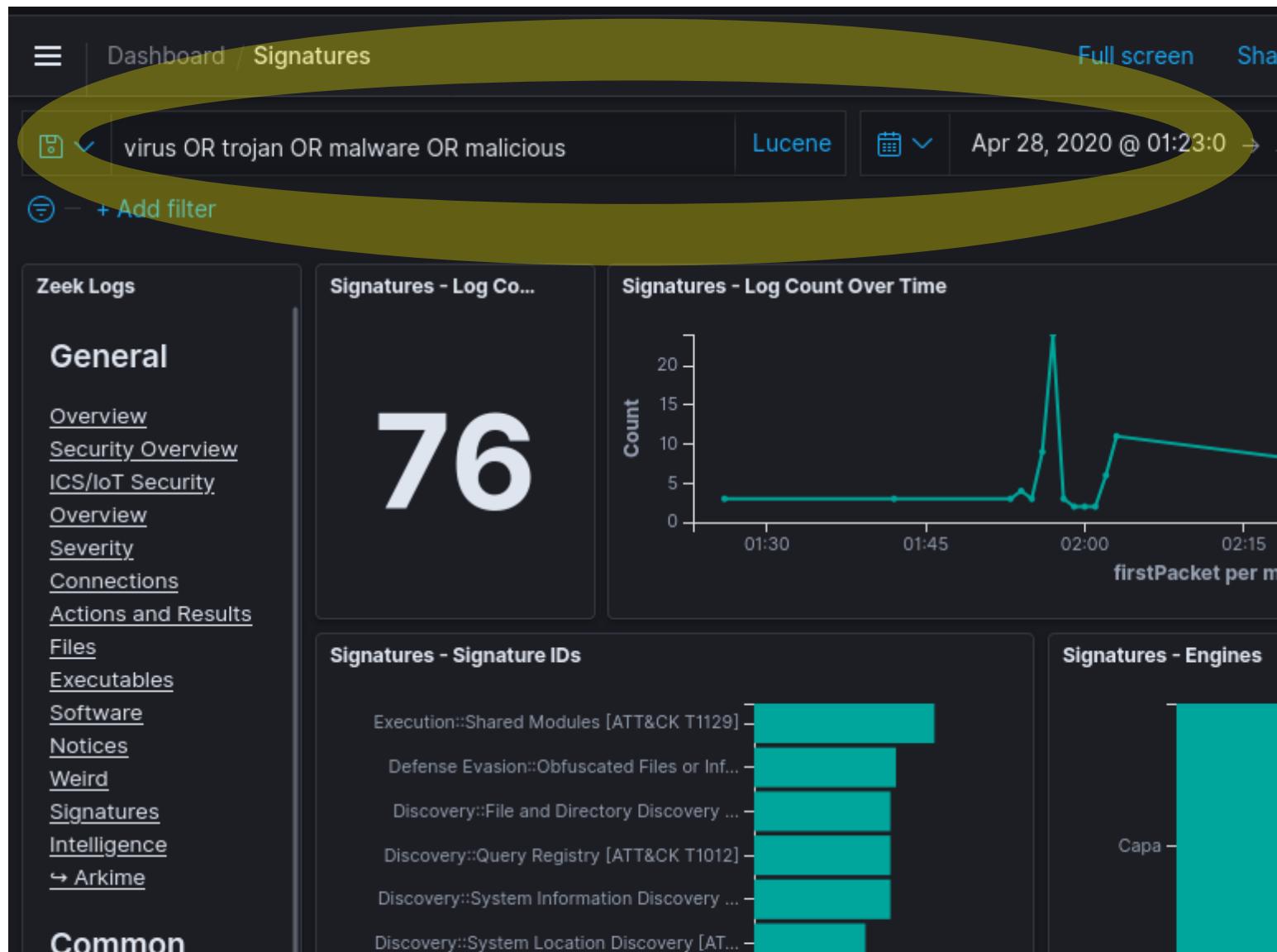
- Notices by Category**: A table showing the count of notices categorized by type. The data is as follows:

Notice Category	Count
SSL::Invalid_Server_Cert	50
ATTACK::Execution	27
ATTACK::Lateral_Movement	6
EternalSafety::EternalSynergy	5
ATTACK::Lateral_Movement_Multiple_Attempts	4
Signatures::Sensitive_Signature	4
ATTACK::Lateral_Movement_Extracted_File	2
EternalSafety::EternalChampion	2
EternalSafety::ViolationNtRename	2
EternalSafety::ViolationTx2Cmd	2
ATTACK::Discovery	1
EternalSafety::DoublePulsar	1
FTP::Bruteforcing	1
Ripple20::Treck_TCP_observed	1

- Connections by Destination Country**: A map visualization showing the distribution of connections by destination country.

Dashboards Filters and Search

- Time filter: define search time frame
- Query bar: write queries in Lucene or DQL syntax
- Filter bar: define filters using a UI
 - Pin filters as you move across dashboards
- Save queries and filters for reuse



Overview Dashboards

- High-level view of trends, sessions and events
- Populated from logs across all protocols
- Good jumping-off place for investigation

The screenshot shows the Malcolm security dashboard. At the top, there's a navigation bar with the title "Malcolm" and a globe icon. Below it, a secondary navigation bar shows "Dashboard / Security Overview". On the left, a sidebar titled "Zeek Logs" lists various sections: General, Overview, Security Overview, ICS/IoT Security Overview, Severity, Connections, Actions and Results, Files, Executables, Software, Notices, Weird, Signatures, Intel Feeds, and Arkime. To the right, a large panel displays "Common Protocols" with icons for DCE/RPC, DHCP, DNS, FTP / TFTP, and others. A vertical sidebar on the far right is titled "Notices by Category" and lists several categories with their counts: SSL::Invalid_Server_..., ATTACK::Execution, ATTACK::Lateral_Mo..., EternalSafety::Etern..., ATTACK::Lateral_Mo..., Signatures::Sensitive..., ATTACK::Lateral_Mo..., EternalSafety::Etern..., EternalSafety::Violat..., EternalSafety::Violat..., ATTACK::Discovery, EternalSafety::Doub..., and FTP::Bruteforcing.

Malcolm

☰ Dashboard / Security Overview

Zeek Logs

General

[Overview](#)

[Security Overview](#)

[ICS/IoT Security Overview](#)

[Severity](#)

[Connections](#)

[Actions and Results](#)

[Files](#)

[Executables](#)

[Software](#)

[Notices](#)

[Weird](#)

[Signatures](#)

[Intel Feeds](#)

[Arkime](#)

Common Protocols

DCE/RPC ● DHCP ● DNS ● FTP / TFTP ●

Notices by Category

Notice Category

SSL::Invalid_Server_...

ATTACK::Execution

ATTACK::Lateral_Mo...

EternalSafety::Etern...

ATTACK::Lateral_Mo...

Signatures::Sensitive...

ATTACK::Lateral_Mo...

EternalSafety::Etern...

EternalSafety::Violat...

EternalSafety::Violat...

ATTACK::Discovery

EternalSafety::Doub...

FTP::Bruteforcing

Notices

- Zeek notices are things that are odd or potentially bad
- In addition to Zeek's defaults, Malcolm raises notices for recent critical vulnerabilities and attack techniques

Malcolm

Dashboard / Notices

Zeek Logs

General

- [Overview](#)
- [Security Overview](#)
- [ICS/IoT Security Overview](#)
- [Severity](#)
- [Connections](#)
- [Actions and Results](#)
- [Files](#)
- [Executables](#)
- [Software](#)
- [Notices](#)
- [Weird](#)
- [Signatures](#)
- [Intel Feeds](#)
- [Arkime](#)

Common Protocols

- DCE/RPC
- DHCP
- DNS
- FTP / TFTP
- HTTP
- IRC
- Kerberos
- LDAP
- MQTT
- MySQL
- NTLM
- NTP
- OSPF
- QUIC
- RADIUS
- RDP
- RFB
- SIP
- SMB
- SMTP
- SNMP
- SSH
- SSL / X.509
- Certificates
- STUN
- Syslog
- TDS / TDS RPC / TDS SQL
- Telnet / rlogin / rsh
- Tunnels

ICS/IoT Protocols

- BACnet
- BSAP
- DNP3
- EtherCAT
- EtherNet/IP
- Modbus
- PROFINET
- S7comm
- Best Guess

Notices - Log Count

108

Notices - Log Count Over Time

Time	Count
23:00:00	108

Notices - Notice Type

Notice Category	Notice Subcategory	Count
SSL	Invalid_Server_Cert	50
ATTACK	Execution	27
ATTACK	Lateral_Movement	6
EternalSafety	EternalSynergy	5
Signatures	Sensitive_Signature	4
ATTACK	Lateral_Movement_Multiple_Attempts	4
EternalSafety	ViolationTx2Cmd	2
EternalSafety	ViolationNtRename	2
EternalSafety	EternalChampion	2
ATTACK	Lateral_Movement_Extracted_File	2

Export: [Raw](#) [Formatted](#)

Security & ICS/IoT Security Overviews

Malcolm

Dashboard / Security Overview

Zeek Logs

General

- Overview
- Security Overview
- ICS/IoT Security Overview
- Severity
- Connections
- Actions and Results
- Files
- Executables
- Software
- Notices
- Weird
- Signatures
- Intel Feeds
- ↳ Arkime

Common Protocols

- DCE/RPC • DHCP • DNS • FTP / TFTP •
- HTTP • IRC • Kerberos • LDAP • MQTT •
- MySQL • NTLM • NTP • OSPF •
- QUIC • RADIUS • RDP • RFB • SIP •
- SMB • SMTP • SNMP • SSH • SSL / X.509 Certificates • STUN • Syslog •
- TDS / TDS RPC / TDS SQL • Telnet / rlogin / rsh • Tunnels

ICS/IoT Protocols

Outdated/Insecure Application Protocols

Application Protocol	Protocol Version	Count
ftp	-	1,063
smb	1	535
tftp	-	64
ntp	3	42
tls	TLSv10	38

Connections by Destination Country (region map)

Signatures - Signature IDs

Defense Evasion:Obfuscated Files or Inf... 50
Execution:Shared Modules [ATT&CK T1129] 27
Discovery:Query Registry [ATT&CK T1012] 6
Discovery:File and Directory Discovery ... 5
Collection:Clipboard Data [ATT&CK T115... 4
Discovery:System Information Discovery ...
Execution:Command and Scripting Interpr.
Signatures:Sensitive_Signature 4
ATTACK:Lateral_Movement_Extracted_File 2
EternalSafety:EternalChampion 2
EternalSafety:ViolationNTRename 2
EternalSafety:ViolationTx2Cmd 2
ATTACK:Discovery 1
EternalSafety:DoublePulsar 1
FTP:Bruteforcing 1
Ripple20:Treck_TCP_observed 1

Clear-text Transmission of Passwords

Application Protocol	Username
ftp	anonymous
ftp	ind@psg420.com
http	Login
http	salesxfer
http	Unknown
ldap	xxxxxxxxxx@xx.xxxx.xxxx.net
ldap	cn=Administrator,cn=Users,dc=cloudshark-a,dc=example,dc=com
ldap	CN=xxxxxx,OU=Users,OU=Accounts,DC=xx,DC=xxx,DC=xxxxx,DC=r
ldap	CN=Tom,CN=Users,DC=cloudshark-a,DC=example,DC=com

Malcolm

Dashboard / ICS/IoT Security Overview

Zeek Logs

General

- Overview
- Security Overview
- ICS/IoT Security Overview
- Severity
- Connections
- Actions and Results
- Files
- Executables
- Software
- Notices
- Weird
- Signatures
- Intel Feeds
- ↳ Arkime

Common Protocols

- DCE/RPC • DHCP • DNS • FTP / TFTP •
- HTTP • IRC • Kerberos • LDAP • MQTT •
- MySQL • NTLM • NTP • OSPF •
- QUIC • RADIUS • RDP • RFB • SIP •
- SMB • SMTP • SNMP • SSH • SSL / X.509 Certificates • STUN • Syslog •
- TDS / TDS RPC / TDS SQL • Telnet / rlogin / rsh • Tunnels

ICS/IoT Protocols

Network Layer

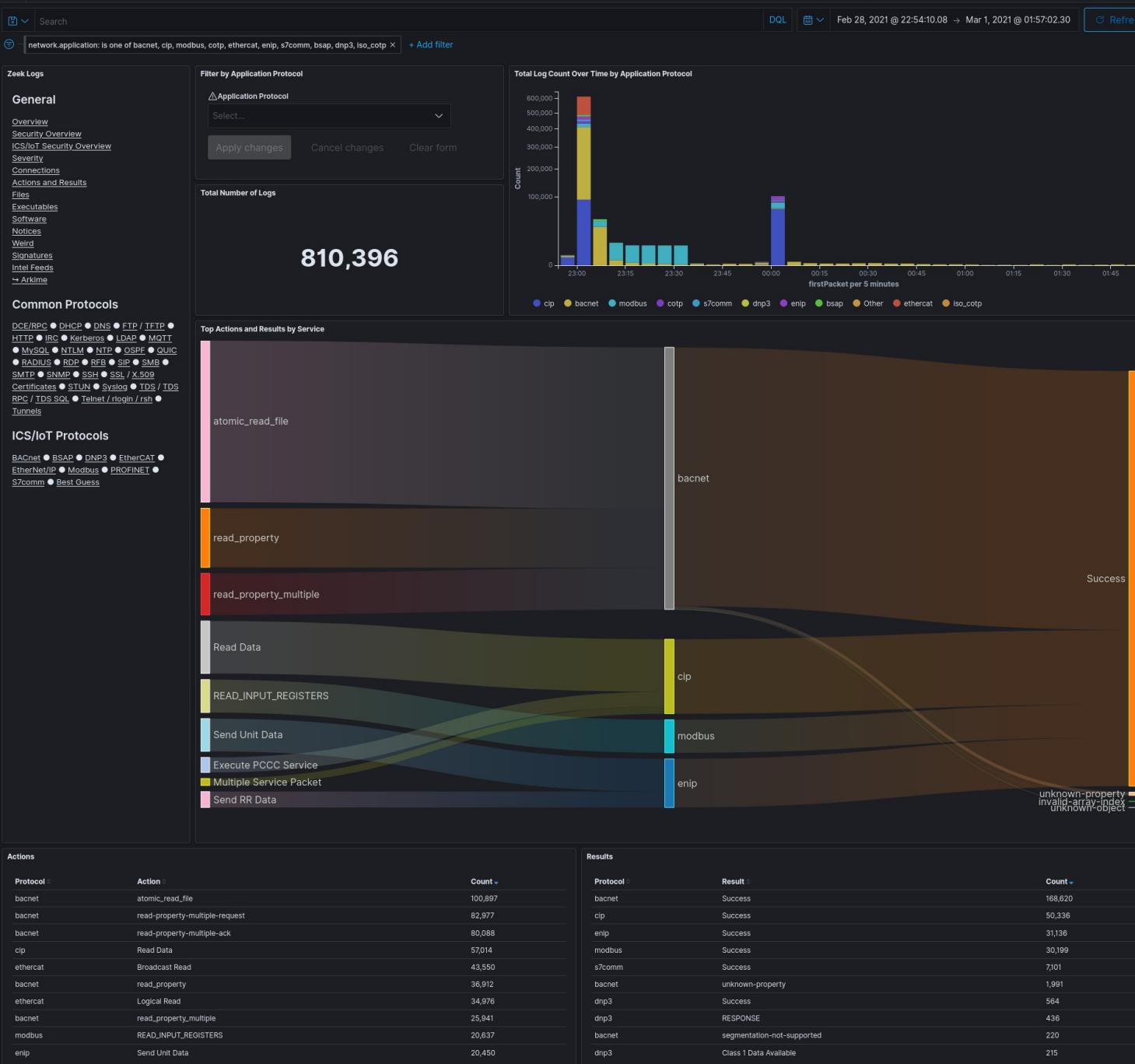
ICS/IoT Log Counts

100,802 ethercat - Count
23,104 cip - Count
16,570 bacnet - Count
12,657 cptp - Count
10,924 s7comm - Count
6,514 modbus - Count
3,829 enip - Count
462 bsp - Count

ICS/IoT Traffic Over Time

ICS/IoT External Traffic

Protocol	Source IP	Source Country	Destination IP	Destination Country	Count
cptp	134.249.62.202	Ukraine	134.249.61.182	Ukraine	679
s7comm	134.249.62.202	Ukraine	134.249.61.182	Ukraine	411
modbus	118.189.96.132	Singapore	118.189.96.132	Singapore	32
modbus	192.168.66.235	-	166.161.16.230	United States	15
s7comm	134.249.62.206	Ukraine	134.249.61.163	Ukraine	5
s7comm	134.249.62.209	Ukraine	134.249.61.182	Ukraine	5



Actions and Results

- Malcolm normalizes “action” (e.g., write, read, create file, logon, logoff, etc.) and “result” (e.g., success, failure, access denied, not found) across protocols

Protocol Dashboards

- Highlight application-specific fields of interest
- Grouped by common IT protocols and ICS/IoT protocols
- ICS protocols
 - BACnet
 - BSAP
 - DNP3
 - EtherCAT
 - EtherNet/IP
 - Modbus
 - PROFINET
 - S7comm

[Intel Feeds](#)

[Arkime](#)

Common Protocols

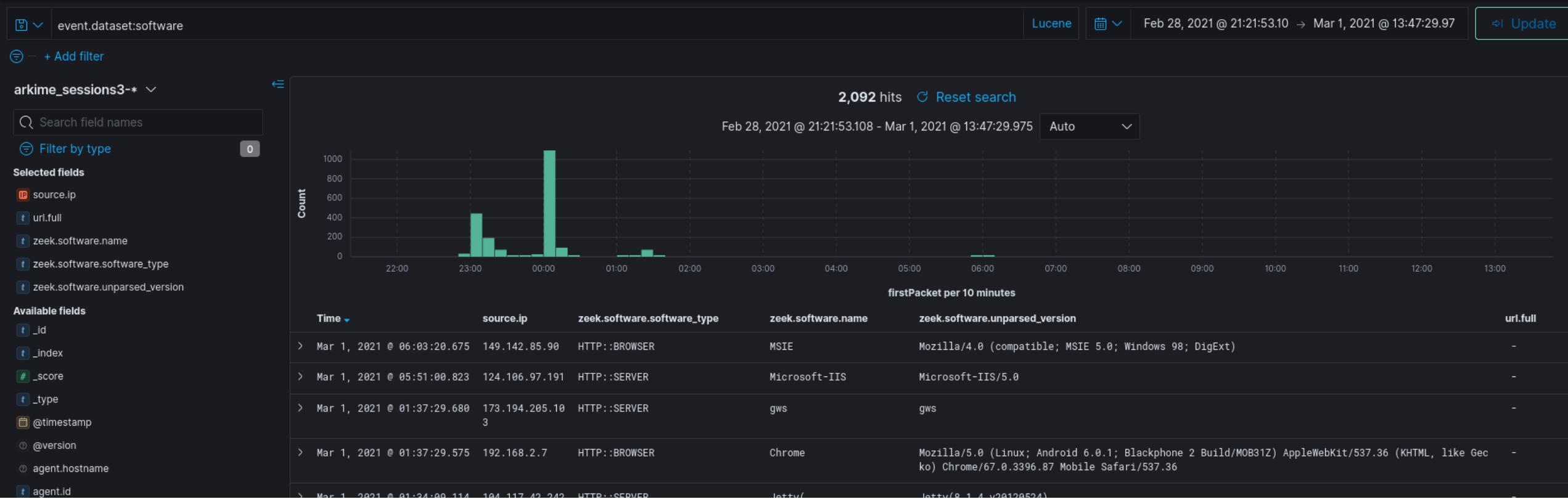
[DCE/RPC](#) ● [DHCP](#) ● [DNS](#) ● [FTP / TFTP](#) ●
[HTTP](#) ● [IRC](#) ● [Kerberos](#) ● [LDAP](#) ● [MQTT](#)
● [MySQL](#) ● [NTLM](#) ● [NTP](#) ● [OSPF](#) ● [QUIC](#)
● [RADIUS](#) ● [RDP](#) ● [RFB](#) ● [SIP](#) ● [SMB](#) ●
[SMTP](#) ● [SNMP](#) ● [SSH](#) ● [SSL / X.509](#)
[Certificates](#) ● [STUN](#) ● [Syslog](#) ● [TDS / TDS](#)
[RPC / TDS SQL](#) ● [Telnet / rlogin / rsh](#) ●
[Tunnels](#)

ICS/IoT Protocols

[BACnet](#) ● [BSAP](#) ● [DNP3](#) ● [EtherCAT](#) ●
[EtherNet/IP](#) ● [Modbus](#) ● [PROFINET](#) ●
[S7comm](#) ● [Best Guess](#)

Discover

- Field-level details of logs matching filter criteria
- Create and view saved searches and column configurations
- View other events just before and after an event



New Visualization

Filter



Area



Controls



Coordinate
Map



Data Table



Gantt Chart



Gauge



Goal



Heat Map



Horizontal Bar



Line



Markdown



Metric



Pie



Region Map



Sankey
Diagram



TSVB



Tag Cloud



Timeline



Vega



Vertical Bar

Custom Visualizations

- Create new visualizations from scratch or based on existing charts or dashboards

Search Syntax Comparison

	Arkime	Dashboards (Lucene)	Dashboards (DQL)
Field exists	zeek.logType == EXISTS!	_exists_:zeek.logType	zeek.logType:*
Field does not exist	zeek.logType != EXISTS!	NOT _exists_:zeek.logType	NOT zeek.logType:*
Field matches a value	port.dst == 22	dstPort:22	dstPort:22
Field does not match a value	port.dst != 22	NOT dstPort:22	NOT dstPort:22
Field matches at least one of a list of values	tags == [external_source, external_destination]	tags:(external_source OR external_destination)	tags:(external_source or external_destination)
Field range (inclusive)	http.statuscode >= 200 && http.statuscode <= 300	http.statuscode:[200 TO 300]	http.statuscode >= 200 and http.statuscode <= 300

Search Syntax Comparison (cont.)

	Arkime	Dashboards (Lucene)	Dashboards (DQL)
Field range (exclusive)	<code>http.statuscode > 200 && http.statuscode < 300</code>	<code>http.statuscode:{200 TO 300}</code>	<code>http.statuscode > 200 and http.statuscode < 300</code>
Field range (mixed exclusivity)	<code>http.statuscode >= 200 && http.statuscode < 300</code>	<code>http.statuscode:[200 TO 300}</code>	<code>http.statuscode >= 200 and http.statuscode < 300</code>
Match all search terms (AND)	<code>(tags == [external_source, external_destination]) && (http.statuscode == 401)</code>	<code>tags:(external_source OR external_destination) AND http.statuscode:401</code>	<code>tags:(external_source or external_destination) and http.statuscode:401</code>
Match any search terms (OR)	<code>(zeek_ftp.password == EXISTS!) (zeek_http.password == EXISTS!) (zeek.user == "anonymous")</code>	<code>_exists_:zeek_ftp.password OR _exists_:zeek_http.password OR zeek.user:"anonymous"</code>	<code>zeek_ftp.password:* or zeek_http.password:* or zeek.user:"anonymous"</code>

Search Syntax Comparison (cont.)

	Arkime	Dashboards (Lucene)	Dashboards (DQL)
Global string search (anywhere in the document)	all Arkime search expressions are field-based	microsoft	microsoft
Wildcards	host.dns == "*micro?oft*" (? for single character, * for any characters)	dns.host:*micro?oft* (? for single character, * for any characters)	dns.host:*micro*ft* (* for any characters)
Regex	host.http == /.*www\.f.*k\.com.*/	zeek_http.host:/.*www\.f.*k\.com.*/	Dashboards Query Language does not currently support regex
IPv4 values	ip == 0.0.0.0/0	srcIp:"0.0.0.0/0" OR dstIp:"0.0.0.0/0"	srcIp:"0.0.0.0/0" OR dstIp:"0.0.0.0/0"
IPv6 values	(ip.src == EXISTS! ip.dst == EXISTS!) && (ip != 0.0.0.0/0)	(_exists_:srcIp AND NOT srcIp:"0.0.0.0/0") OR (_exists_:dstIp AND NOT dstIp:"0.0.0.0/0")	(srcIp:* and not srcIp:"0.0.0.0/0") or (dstIp:* and not dstIp:"0.0.0.0/0")

Search Syntax Comparison (cont.)

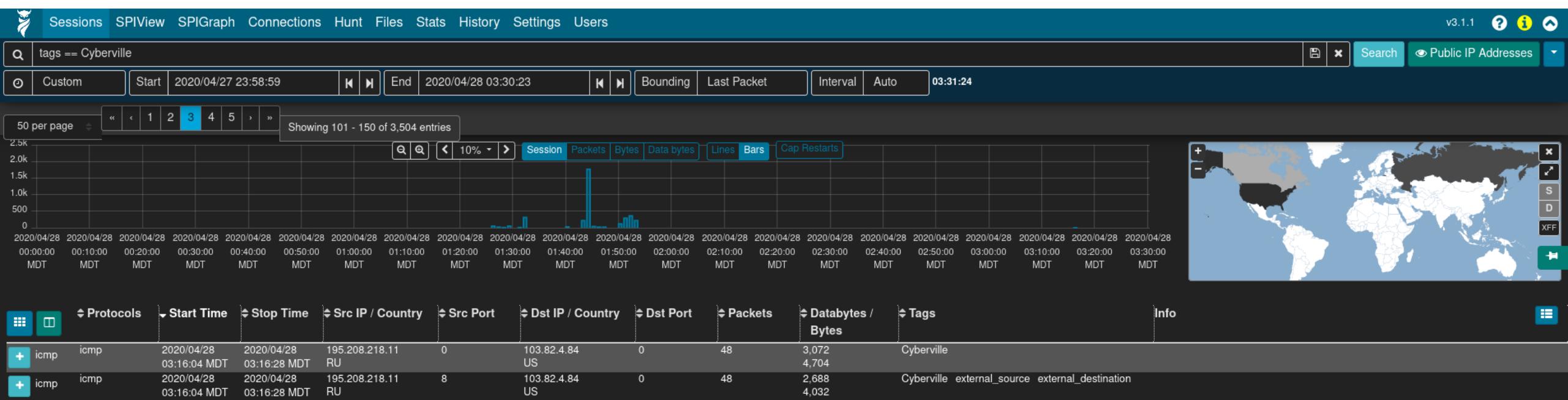
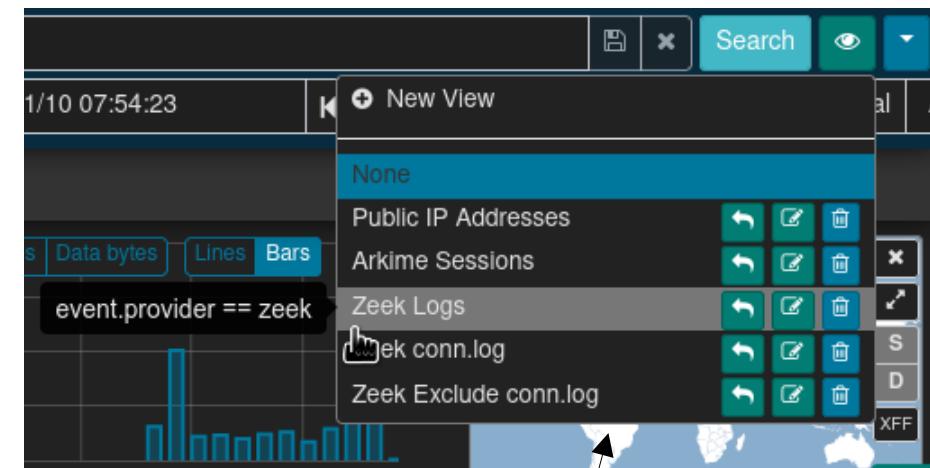
	Arkime	Dashboards (Lucene)	Dashboards (DQL)
GeolP information available	country == EXISTS!	_exists_:zeek.destination_geo OR _exists_:zeek.source_geo	zeek.destination_geo:* or zeek.source_geo:*
Zeek log type	zeek.logType == notice	zeek.logType:notice	zeek.logType:notice
IP CIDR Subnets	ip.src == 172.16.0.0/12	srcIp:"172.16.0.0/12"	srcIp:"172.16.0.0/12"
Search time frame	Use Arkime time bounding controls under the search bar	Use Dashboards time range controls in the upper right-hand corner	Use Dashboards time range controls in the upper right-hand corner
GeolP information available	country == EXISTS!	_exists_:zeek.destination_geo OR _exists_:zeek.source_geo	zeek.destination_geo:* or zeek.source_geo:*



- Front end for **both** enriched Zeek logs and Arkime sessions
 - Malcolm's custom Arkime Zeek data source adds full support for Zeek logs to Arkime, including ICS protocols
- Filter by Zeek logs or Arkime sessions; or, view both together
- “Wireshark at scale”: full PCAP availability for
 - viewing packet payload
 - exporting filtered and joined PCAP sessions
 - running deep-packet searches
- <https://localhost>

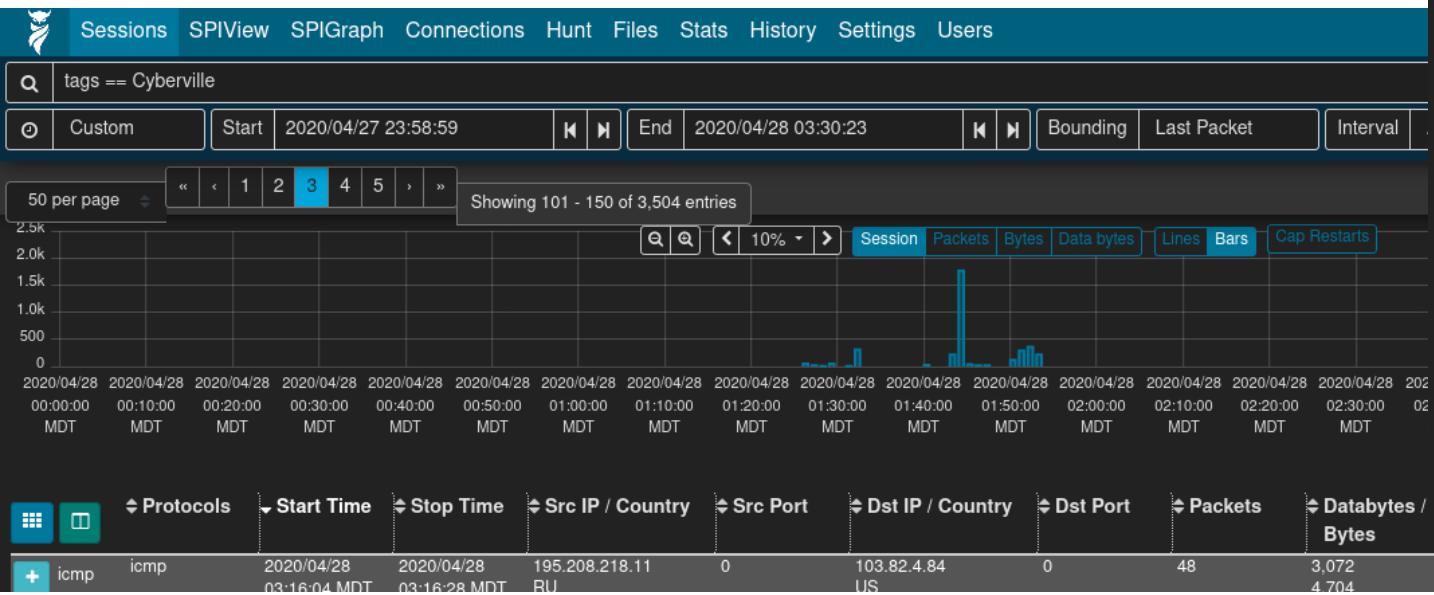
Arkime Filters and Search

- Time filter: define search time frame
- Map filter: restrict results to geolocation
- Query bar: write queries in Arkime syntax
- Views : overlay previously-specified filters on current search



Sessions

- Field-level details of sessions/logs matching filters
- Similar to Dashboards' Discover



The screenshot shows the Sessions interface with the following details:

- Navigation Bar:** Sessions, SPIView, SPIGraph, Connections, Hunt, Files, Stats, History, Settings, Users.
- Search Bar:** protocols == http && tags == external_destination
- Filter Bar:** Custom, Start: 2020/11/11 06:23:48, End: 2021/05/30 06:00:53.
- Table Headers:** Log Type, Malcolm Data Source, Malcolm Node, Originating Host, Originating GeoIP Country, Originating GeoIP City, Responding Host, Responding GeoIP Country, Responding GeoIP City, Originating Port, Responding Port, Related IP, Protocol, Service, Service Version, Action, Result, Severity, Risk Score, Severity Tags, File Magic.
- Table Data:** Showing 1 - 50 of 12,150 entries. The data includes:
 - Log Type: http
 - Malcolm Data Source: zeek
 - Malcolm Node: filebeat
 - Originating Host: 217.226.31.170
 - Originating GeoIP Country: Germany
 - Originating GeoIP City: Bremen
 - Responding Host: 124.106.97.191
 - Responding GeoIP Country: Philippines
 - Responding GeoIP City: Santa Elena
 - Originating Port: 4230
 - Responding Port: 80
 - Related IP: 217.226.31.170 124.106.97.191
 - Protocol: tcp
 - Service: http
 - Service Version: 1.1
 - Action: GET
 - Result: Bad Gateway
 - Severity: 20
 - Risk Score: 20
 - Severity Tags: External traffic
 - File Magic: text/html

Zeek http.log

The screenshot shows the Zeek http.log interface with the following details:

- Navigation Bar:** Sessions, SPIView, SPIGraph, Connections, Hunt, Files, Stats, History, Settings, Users.
- Filter Bar:** Pipeline Depth: 1, Request Method: GET, URI: /_vti_bin/.../winnt/system32/cmd.exe?c+dir+x:\c+dir+x:\c+dir+x:\, Version: 1.1.

Packet Payloads

- Displayed for Arkime sessions with full PCAP (i.e., not Zeek logs)
- File carving on the fly
- Download session PCAP
- Examine payload with CyberChef

Source

```
GET /PostExploitation/PCAnyPass.exe HTTP/1.1
Accept: text/html, application/xhtml+xml, /*
Referer: http://10.10.10.11/PostExploitation/
Accept-Language: en-US
User-Agent: Mozilla/5.0 (compatible; MSIE 9.0; Windows NT 6.1; Trident/5.0)
Accept-Encoding: gzip, deflate
Host: 10.10.10.11
Connection: Keep-Alive
```

Destination

```
HTTP/1.0 200 OK
Server: SimpleHTTP/0.6 Python/2.7.17
Date: Fri, 17 Apr 2020 19:21:32 GMT
Content-type: application/x-msdos-program
Content-Length: 49152
Last-Modified: Fri, 16 Apr 2010 19:09:50 GMT
```

[PCAnyPass.exe](#)

Export PCAP

- Creates a new PCAP file from filtered sessions
- Include open, visible or all matching sessions
- Apply “Arkime Sessions” view to sessions first
- Narrow as much as possible prior to exporting (huge PCAP files are a pain)

The screenshot shows the Arkime interface with the following details:

- Top Navigation:** Sessions, SPIView, SPIGraph, Connections, Hunt, Files, Stats, History, Settings, Users.
- Search Bar:** country != US && protocols == http
- Filter Bar:** Custom, Start: 2021/02/28 23:59:11, End: 2021/03/01 00:28:26, Bounding, Last Packet, Interval: Auto, Duration: 00:29:15.
- Session View Buttons:** Open Items, Visible Items, Matching Items, Include: same time period, linked segments (slow), Filename: US_HTTP.pcap.
- Export Options:** Export PCAP.
- Bottom Filtering:** Protocols: tcp, http, Start Time: 2021/03/01, Stop Time: 2021/03/01, Src IP / Country: 10.0.52.164, Src Port: 2550, Dst IP / Country: 61.8.0.17, Dst Port: 80, Packets: 7,195, Databytes / Bytes: 5,160,414, Tags: HTTP, out-of-order-dst.
- Bottom Status:** URI: mirror.pacific.net.au/openoffice/stable/2.0.0/OOo_2.0.0_Win32Intel_install.exe
- Right Panel:** A world map showing traffic distribution.

SPIView

- Explore “top n ” and field cardinality for all fields of both Arkime sessions and Zeek logs
- Apply filters or pivot to Sessions or SPIGraph view for field values of interest
- Limit search to ≤ 1 week before using (it runs many queries)



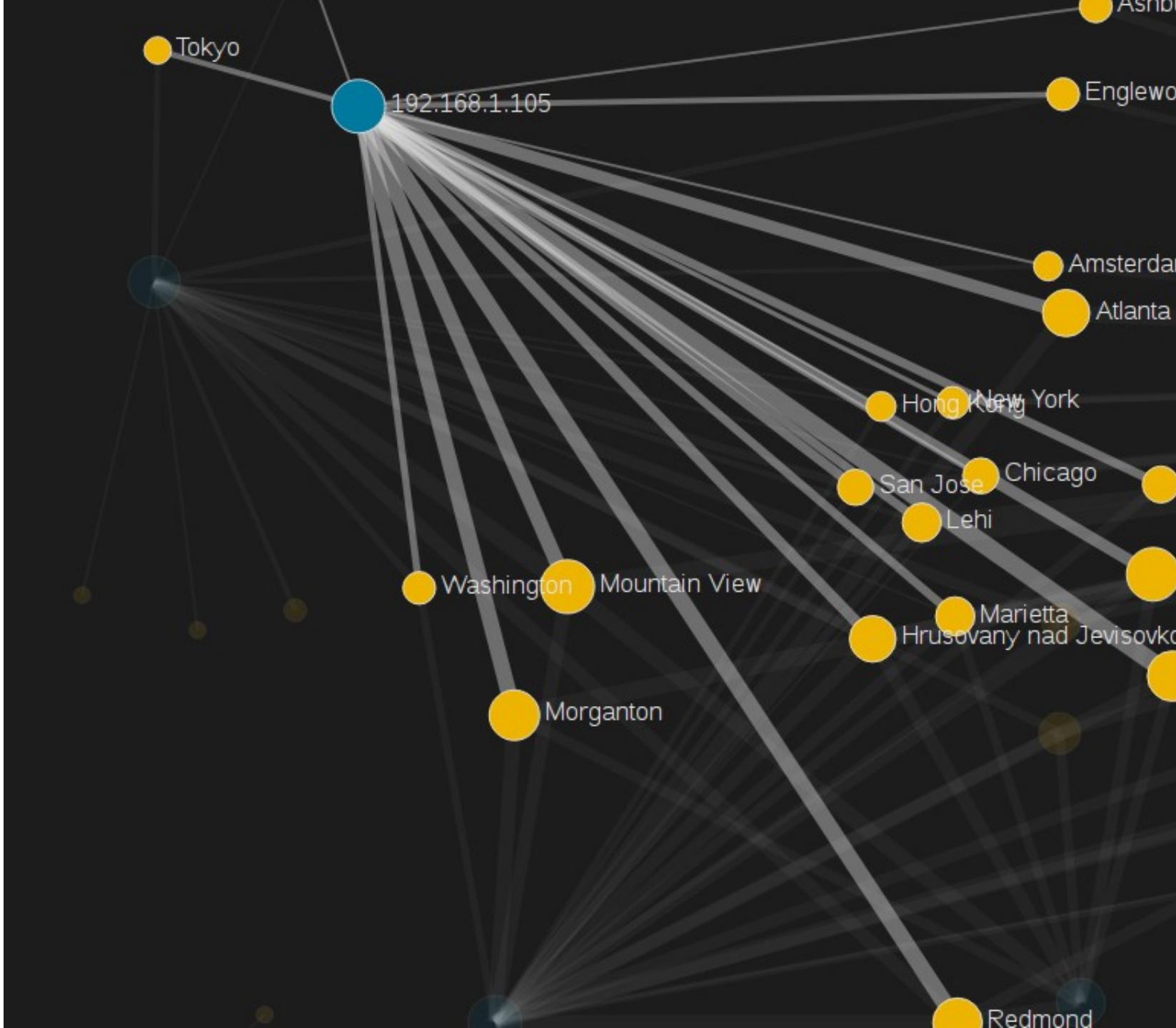
SPIGraph

- View “top n ” field values chronologically and geographically
- Identify trends and patterns in network traffic



Connections

- Visualize logical relationship between hosts
- Use any combination of fields for source and destination nodes
- Compare current vs. previous (baseline) traffic



Packet Search (“Hunt”)

- Deep-packet search (“PCAP grep”) of session payloads
- Search for ASCII, hex codes or regular expression matches
- Apply “Arkime Sessions” view to sessions first

Sessions SPIView SPIGraph Connections Hunt Files Stats History Settings Users v3.1.1 ? ! 🔍

protocols == http Search Arkime Sessions

All (careful) Start 1969/12/31 17:00:00 End 2021/12/06 12:10:02 Bounding Last Packet

Creating a new packet search job will search the packets of 2,906 sessions. Create a packet search job

Hunt Job History

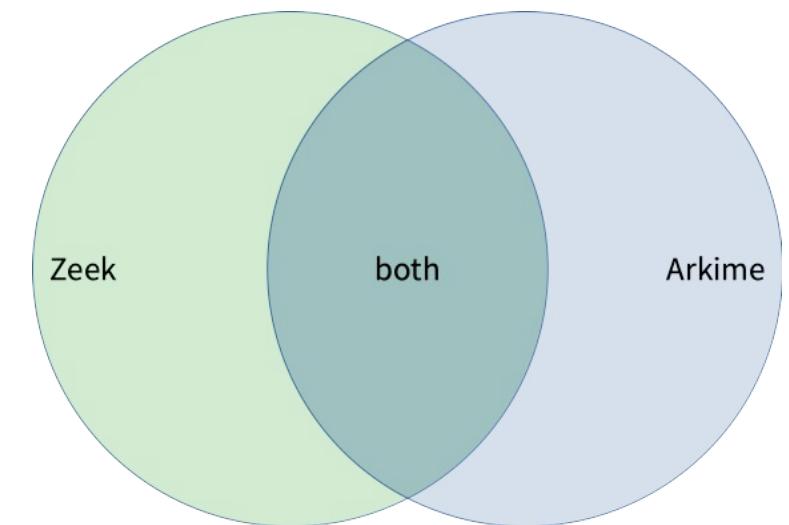
Search your packet search job history 50 per page 1 Showing 1 - 1 of 1 entries

Status	Matches	Name	User	Search text	Notify	Created	ID
<input checked="" type="checkbox"/> 100%	141	HTTP with password		password (ascii)		2021/12/06 12:12:27 MST	s5YpkX0BTA40FhD4X7dA

This hunt is **finished**
Found 141 sessions matching **password** (ascii) of 2,908 sessions searched
Created: 2021/12/06 12:12:27 MST
Last Updated: 2021/12/06 12:12:32 MST
Examining 500 raw source and destination packets per session
The sessions query expression was: **protocols == http**
The sessions query view was: **Arkime Sessions**
The sessions query time range was from 1969/12/31 17:00:00 MST to 2021/12/06 12:10:02 MST

Data Source Correlation

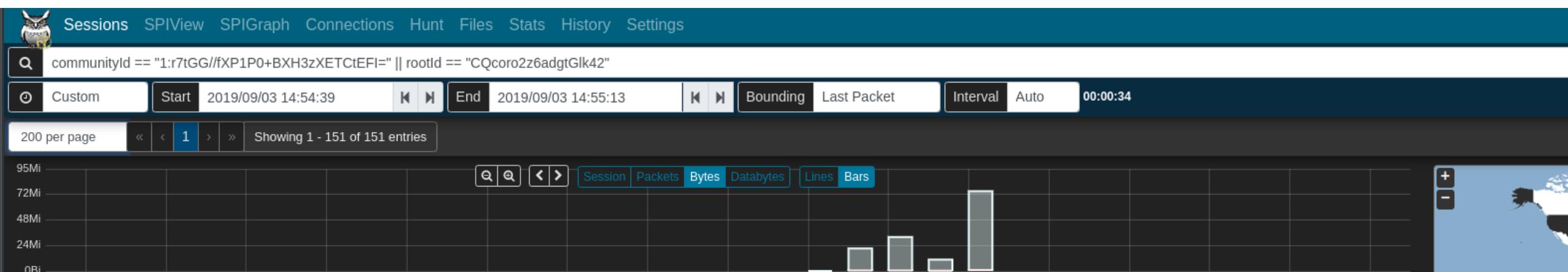
- Search syntax is different between Arkime and Dashboards (and in some cases, so are field names)
 - See search syntax comparison table, Malcolm and Arkime docs
- Despite considerable overlap, there are differences in protocol parser support between Zeek and Arkime
 - Learning the strengths of each will help you more effectively find the good stuff



Correlate Zeek Logs and Packet Payloads

- Correlate Zeek logs and Arkime sessions using common fields
- communityId fingerprints flows in both and can bridge the two
- rootId / zeek.uid filters Zeek logs for the same session
- Filter community ID OR'ed with Zeek UID to see all Arkime sessions and Zeek logs for the same traffic

```
communityId == "1:r7tGG//fXP1P0+BXH3zXETCtEFI=" || rootId == "CQcoro2z6adgtGlk42"
```



File Analysis



- Zeek can “carve” file transfers from common protocols
- Malcolm can examine carved files and flag hits
 - ClamAV - open source antivirus engine
 - YARA - pattern matching swiss army knife
 - Capa - portable executable capabilities analyzer
 - VirusTotal - online database of file hashes
 - requires API token and internet connection
- Triggering files can be saved to
`zeek-logs/extract_files` under Malcolm
directory for further analysis
 - Be careful! Carved files may contain live malware!



Signatures

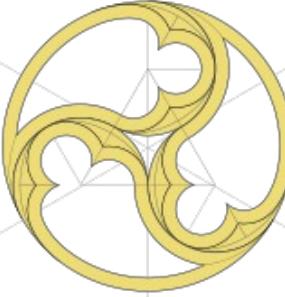
- Signatures dashboard in Dashboards shows scanned file hits
- Use `zeek.fuid` field in *Signatures - Logs* table to pivot to connection UID (`zeek.uid`) and other logs with pertinent session details



Search Tips

- Always check your search time frame
- “Zoom in” (apply filters) for a particular field value, pivot to another field then “zoom out” (remove filters)
- Most UI controls can work with any data field (1000+)
- Filter on `zeek.logType` (e.g., `conn` to see `conn.log`)
- Filter on `protocol` or both Arkime and Zeek regardless of data source (e.g., `protocol:http` in Dashboards and `protocols == http` in Arkime)
- Use tags

Malcolm



Thank you!

Visit [Malcolm on GitHub](#) to read the docs, make suggestions, report issues and st★r to show your support!

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