Open Threat Hunting Framework

V0.1

Table of Content

Table of Figures

Figure 22: Example Threat Assessment - assessing likelihood

Acknowledgements

Thank you to everyone who has helped in various ways to create this project. We hope we can continue to grow this framework to help more people succeed in threat hunting.

Introduction

Establishing or maturing an effective threat hunting program is a challenging task compared to approaching threat hunting from an unofficial perspective where existing security resources execute ad-hoc hunts in their spare time however, a well-designed and dedicated threat hunting program can be a major driver in changing the security culture of an entire organization.

The purpose of this document is to provide foundational understanding of Threat Hunting and introduce the Open Threat Hunt Framework (OTHF) which are practical guidelines to developing and maturing an effective threat hunting program.

The goal of the OTHF is to provide organizations with a framework which provides guidance on implementing core organizational, operational, and technical components to launch and mature threat hunting operation. The OTHF is completely vendor and tool agnostic and not meant to be an exhaustive resource on threat hunting techniques or analysis but instead designed to present organizations with often overlooked pieces of threat hunting that have a massive impact on the success of the program.

While the overall OTHF is designed for organizations attempting to launch and mature a dedicated threat hunting program staffed with dedicated resources, the OTHF is modular by design to accommodate organizations who are unable to staff a dedicated team but can still leverage the operational components to begin or improve threat hunting within their organization.

Foundational

Organizational Support

"Going it alone, you won't last a day out there" – Sandor Clegane, Game of Thrones

To launch and mature an effective threat hunting program, it is critical to have buy-in for executive leadership and sometimes that can be a difficult conversation to heave with leadership. A major security benefit form threat hunting is that is offers the ability to verify assumptions about the design, controls, and behaviors of a network but it also operates within a space that assumes that existing security protections have failed. Security investments continue to increase year over year so when approaching leadership to support investing in a threat hunting team, consider the following guidelines.

Gaining the support of the chief security officer (CSO) or chief information security officer (CISO) is critically important, and efforts should be made to gain executive support beyond the security organizational boundaries. The more executive support a threat hunting program can get the better. If a threat hunting program does not gain executive support, the effectiveness and growth of the program will be limited.

Depending on the organization, obtaining long term support from executives can be challenging but demonstrating the value of threat hunting by showing how threat hunting can help reduce risk, reduce dwell time, and enhance existing security teams within the organization can help leadership understand the value add and buy into the effort.

The following are some data points which can be used to gaining leadership support:

- If your organization has experienced any breaches, present dwell time, impact, and cost data associated with the breaches
- Present third-party evidence related to the cost of data breaches

- Present dwell time data from third-party resources
- Compare recent penetration testing or red team exercise activities against existing security tooling highlighting the gaps in detections
- Consider scheduling a compromise assessment and using the results as data point to highlight identified risks, threats, or lack of visibility

The following are some talking points to discuss with leadership regarding the value-add of threat hunting:

- Reduce the average time to detect threats
- Increase the quality of automated detections to reduce alert fatigue and improve security operations
- Ensure security controls are adequate
- Reduce costly incident response activities
- Protect intellectual property and brand reputation

Be prepared to submit an official proposal to start a threat hunting program including an executive summary, justification, cost schedule and deliverables. The following sections within this framework will be valuable resources in developing the proposal:

- Resources and Staffing
- Data and Technology Audit
- Metrics

It is quite ok to start small, demonstrate value, and then expand threat hunting operations as the team provides value to the organization. Details regarding short- and long-term goals and milestones should be included within the proposal.

Organizational Placement

While not a critical component to begin or run an effective threat hunting program at an organization, the placement of the threat hunting team within an organization can directly impact how well the value threat hunting is bringing to the organization is communicated to leadership.

The placement of the threat hunting team may depend on the staffing model of the threat hunting program. If threat hunting is going to be executed as a part time function within an existing team obviously, changing the organizational layout will be challenge however to maximize the effectiveness and growth opportunities for a threat hunting program, it is best if the threat hunting team directly informs security leadership such as the CISO or CSO. Directly communication lines between threat hunters provides leadership direct, unfiltered input into the state of security within the organization.

Threat Hunting Definition

"Ask 10 security professionals for the definition of threat hunting and you'll get 11 answers"

Each organization that wants to launch or has a threat hunting program must define what threat hunting means to the organization and that definition should be driven by the mission statement of the threat hunting program. The OTHF is not designed to act as the authority of what is or isn't threat hunting because threat hunting means a lot of different things to a lot of different people and that's ok. The only requirements regarding the definition of threat hunting that the OTHF includes is:

1. The organization should decide on and document the definition of threat hunting
2. The definition of threat hunting should be driven by the mission statement of the threating hunting program

Considerations organizations should include when defining threat hunting:

- Avoid hunting for activities that are already being detected by differentiating between proactive from reactive efforts
    - If you define threat hunting as an activity that involves purposefully seeking out evidence of malicious activities within the environment that did not generate security alerts, the organization can avoid duplications of effort and maximize value add to the organization. Additionally, if an organization specifically calls out how threat hunting is a proactive approach to cybersecurity, it can eliminate confusion as to how threat hunting differs from incident response or security operations responding to an alert.
- Describe threat hunting as a dedicated, repeatable process
    - Threat hunting benefits from a methodical approach. From the threat hunters perspective, hunters will benefit from a disciplined approach to understand the threats applicable to the target environment, understand their respective techniques, tactics, and procedures, and then use that information to determine what clues to look for that might indicate an attack underway. Additionally, a well-defined process makes it easier to track improvements, increase collaboration, and provide quality control.
- The value of including language to ensure threat hunting is based upon a hypothesis
    - The main advantage of leveraging a hypothesis-based threat hunting model is that it ensures that a threat hunt is testable and provides guidelines to determine success or failure. Additionally, a hypothesis provides a clear statement of the question that the hunter intends to investigate. Without a hypothesis, a threat hunting can become unfocused and difficult to conclude any sort of concrete findings. There are activities within threat hunting that may not have a formal hypothesis such as generation observations on the behavioral data of

systems or users within the network such as “I wonder how many users actually use PowerShell on a day-to-day basis?” however such observational research should be used to create a hypothesis-based threat hunt.

Example definitions of threat hunting:

- Threat Hunting is a dedicated, continuous, hypothesis-based search methodology to reduce the time to detect adversaries operating within an environment that have yet to be detected.
- “Threat hunting is the practice of proactively searching for cyber threats that are lurking undetected in a network”.[1]
- “Cyber threat hunting is a proactive security search through networks, endpoints, and datasets to hunt malicious, suspicious, or risky activities that have evaded detection by existing tools.”[2]
- “Threat hunting is the practice of searching for cyber threats that might otherwise remain undetected in your network.”[3]
- “"a focused and iterative approach to searching out, identifying, and understanding adversaries internal to the defender's networks.”[4]

Mission Statement

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[1] https://www.crowdstrike.com/cybersecurity-101/threat-hunting/

[2] https://www.trellix.com/en-us/security-awareness/operations/what-is-cyber-threat-hunting.html

[3] https://www.checkpoint.com/cyber-hub/cloud-security/what-is-threat-hunting/

[4] https://www.sans.org/white-papers/who-what-where-when-why-how-effective-threat-hunting/

It is essential that organizations set the clear expectations, principles, and a vision for the Threat Hunting Team. A mission statement is a critical component to help communicate the purpose and direct the threat hunting program in the right direction. The growth and success of the threat hunting program will be dependent on short-, medium-, and long-term goals and the mission statement provides an invaluable navigation tool to define and obtain goals. It is important to note that a mission statement is not meant to be something used during just the launch of the threat program but a navigational beacon that provides direction as the program grows and matures. Additionally, a well-constructed mission statement will help the team see the meaning and purpose of their work by giving them clear reasons their job benefits a larger goal. The best part about mission statements is that they can always been changed. Do not be afraid to replace or revise your mission statement as your threat hunting program grows and matures.

Consider the following example mission statement:

To be the driving force in custom automated adversary detection targeting XYZ .

From this mission statement, the reader immediately understands that this threat hunting program is focused on hunting for adversary activities and creating automated detections specific to the organization so it's reasonable to assume that a big focus of this threat hunting program would be identifying and understanding relevant adversaries and developing threat hunts that would transition well to custom automated detections.

Here are some recommendations for building a mission statement for threat hunting:

- Keep it concise and do not exceed more than one or two sentences and
- Consider including language to ensure that threat hunting is meant to compliment existing security teams, not replace them
- Get feedback and include the team members in its development
- It's not important to include details into how goals will be achieved

- Attempt to include components that align with the mission statement and core values of the overall organization

Strategy

The strategy of a threat hunting program is a thoughtfully constructed plan or approach that outlines how the program will achieve the mission. It's worth nothing that strategies play a role in how goals and objectives are accomplished as well but for the purposes of this section, we will focus on strategy as it relates to the program's mission.

A well-crafted strategy provides a clear roadmap sets the tone of the actions people in the organization should take and identify the priorities to achieve the desired goals. It is important to note that a strategy is not a mission statement. When applied properly a strategy will dictate how resources will be allocated to accomplish the mission. Therefore, threat hunting organizations should develop a mission statement first before developing a strategy for the threat hunting program.

It is worth noting that an organization's strategy is dynamic as it will continue to change as it adapts to new goals and objectives. Strategies are critical to the success of a threat hunting program because they are the driving force behind creating the plans and actions to accomplish goals.

Figure 1: Setting up Threat Hunting Mission, Strategy, Goals and Objectives

Goals and Objectives

Every threat hunt program, in fact every hunter, must have a goal in order to succeed. A goal is the desired result that a program or hunter plans to accomplish. Goals should be specific, realistic, and attainable and usually have a deadline. Goals can either be short term or long term and can be any of these types:

Long-term goals:

Big picture goals that often stretch over a significant amount of time and require accomplishing short term goals to complete.

Example: Make the threat hunting program a leader within the security organization

Short-term goals:

How long-term goals are broken down into manageable pieces. Short-term goals tend to be easily measured and associated with a specific time period.

Example: Increase awareness of the value threat hunting will bring to the organization

Performance-based goals:

Performance-based goals are associated with specific tasks or objectives that are easy to measure or evaluate. Performance-based goals are often associated with a specific time period.

Example: Migrate 100 threat hunts to automated detections by the end of Q1.

Quantitative goals:

Quantitative goals are directly associated on hard data such as percentages, numbers, or statistics.

Example: Reduce SOC false positive triage efforts by 25% by redesigning existing automated detections through threat hunting process.

Qualitative goals:

Qualitative goals are ones that are felt more than measured. The achievement of qualitative goals are not based on hard data but on the impact on the satisfaction and worth of the person or program.

Example: Improve relations between SOC and threat hunting team.

Outcome-oriented goals:

Outcome goals are centered on the end-results specifically stating what the goal is designed achieve. Outcome goals do not detail how the end-result will be achieved but rather states clearly what is to be achieved.

Example: Establish and implement a threat hunting process

Process-oriented goals:

Process goals are detailed plans of action and track the progress of steps taken to advance. Process goals are about the way the threat hunt team does things, not about the results.

GOST Framework

The Harvard Business Review's Robert Kaplan 95% of employees are unaware of or do not understand their company's strategy[5] indicating that there is clear disconnect between a company's overarching strategic management plan and the people who are meant to execute it. The GOST framework stands for Goals Objectives Strategy and Tactics and provides a way to bring visibility and clarity to what an organization is trying to do and how they are going to do it.

On a smaller scale, threat hunters should be aware of the overall strategy of the threat hunting organization. When threat hunt teams do not understand what the team is trying to accomplish, why it is important, and what is expected of them it can result in confusion, decreased morale, and a lack confidence in leadership.

Breaking down the GOST framework, you can see that there is a clear distinction between the components of the framework in terms of what the team is trying to accomplish and how they are meant to accomplish it.

Goals are what you want to achieve broadly, and they are qualitative. Objectives are quantitative measurements or numeric targets that describe the specific outcomes that define your goal such as marketing penetration, profit, and revenue.

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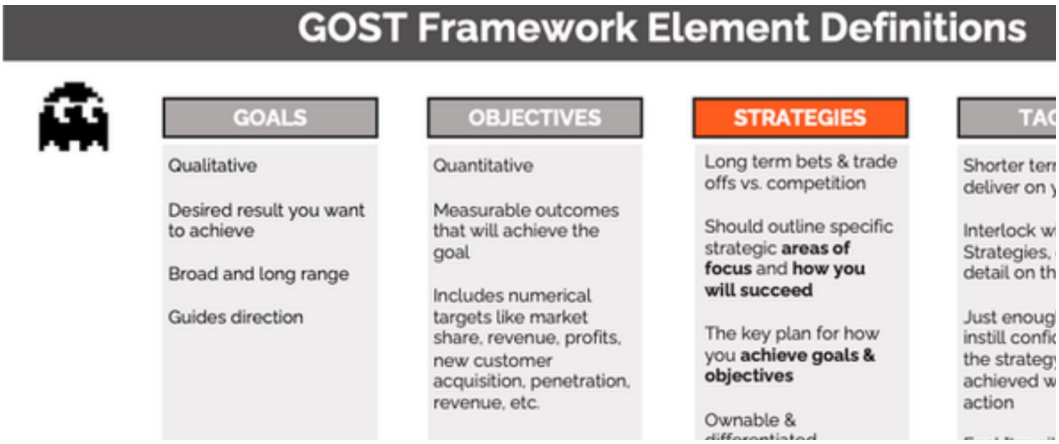
[5] https://pubmed.ncbi.nlm.nih.gov/16250626/

Strategy is the high-level plan you will follow to achieve your goals and tactics are specific actions you will take to achieve your goals.

Figure 17: GOST Framework[6]



Strategy Kiln GOST Framework[7]

Structure

Like all aspects of security, having a solid foundation to build on is essential, but where do you go from there? What are the key parts that make up a hunt program? What are the right data sources? Who should be your hunters?

Answering these questions and deciding when and how to hunt can be overwhelming enough to stop some teams before they ever get the chance to do their first data carve. This section will guide you on the path to building your first hunt team by helping you determine who the right people are to be your hunters and what their roles will be within the team.

Roles and Responsibilities

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[6] https://ebrary.net/116529/management/gost_framework

[7] https://www.strategykiln.com/post/gost-busters-goals-objectives-strategies-and-tactics-explained-with-an-amazon-example

Hunter Roles

Principal Threat Hunter

This individual should have extensive experience with all aspects of information security and how they tie together. They should be able to conduct advanced analysis while using best practices that they have either helped develop or understand at a level that allows them to transfer that knowledge to lower level hunters. They should be able to develop dashboards and reports to communicate findings within the team and with senior leadership. Principal Threat Hunters should be involved in selecting the technologies that enable the most effective hunts for their organization. Using findings from hunt activities they should be able to provide feedback and recommendations on how to improve the organization's security program.

Senior Threat Hunter

This individual has a strong grasp of security technologies and architecture. They should be able to conduct analysis of host activity and network traffic across a wide variety of platforms and technologies. A Sr. Threat Hunter should understand a wide range of threat intelligence and adversary tactics, techniques, and procedures (TTPs). Using intelligence found through hunt campaigns this individual should be able to assist in, or lead, the development of appropriate countermeasures. They should participate in the creation and documentation of threat hunting hypothesis and track the effectiveness of the associated hunts.

Threat Hunter

A new threat hunter should have experience with network and/or host based intrusion analysis. They should have a good understanding of how Windows, Linux, and Mac operating systems function. They should have some experience assessing threat intelligence to identify intelligence that is relevant to the organization and be familiar with adversary techniques and attack lifecycles. The ability to communicate clearly and document findings for later research, use, or escalation is also key to this role.

Hunter Mindset

There are things that make a good threat hunter that are less technically quantifiable and yet have an impact on the success of the hunter both in terms of what the organization gains as well as how much the individual enjoys the role.

The following are several traits you might take into account when considering individuals for a threat hunting role:

- Offensive security experience. The ability to think like an attacker will allow easier hypothesis creation as the hunter can see themselves in that role and identify areas that they would consider an area of organizational weakness worth targeting.
- Investigational mindset. Identify who within your team likes to chase down a problem until they find a solution. Not only trying to understand if something is there, but why and how it exists in the first place. The natural root cause analysis seekers. The puzzle solvers.
- Attention to detail. Find those who notice small errors or patterns in everyday things. If an individual is quick to point out a typo in a PowerPoint presentation that no one else noticed, or a pattern in the way someone speaks, the behavior of coworkers, or how information is displayed, this is a good hunter. They recognize patterns, how something should look, and when something deviates from the norm.

Hunters really need to understand how the area they're hunting in should work. Understanding what something looks like when it's functioning normally allows you to determine when there's a potential issue. When a hunter sees a protocol not working the way it's outlined in the RFC, or a process spawned by an application it shouldn't normally have a relationship with, that's when they're going to find something interesting. Remember, threat hunting is an exercise in outlier detection and it's only possible to find an outlier when you know what the baseline is.

Staffing

When building a threat hunting team determining the right people to participate in your hunts can seem like a difficult task. Balancing experience and specialization while ensuring resources for other aspects of your security program. But it's not just about who the right people are, it's about how many people should be hunting as well.

Deciding the number of staff to dedicate to a particular offering can be challenging. Each organization has a different sized SOC, is staffed at different levels, and with different roles and responsibilities. Some organizations have no dedicated threat hunters at all, while others have full teams of hunters at their disposal. We'll approach staffing with those differences in mind.

Skills Matrix

Threat hunting requires varied skills, and understanding where those skills lie within your hunt team, as well as the broader SOC/CIRT is invaluable. One of the best ways of doing this is with a skills matrix. A skills matrix is like a map of the different competencies that exist within a team. It allows you to not only understand where your team is the strongest, but also identifies areas that require development and any gaps in coverage. This is useful for training and development opportunities, but also a great resource when considering hiring additional members of the team.

Access to the skills matrix should be for management or senior leadership only. Often times when this type of resource is expected to be public, individuals will overstate their skills in areas that they believe will reflect poorly on them within the team. This is not a tool for shaming, it's a tool for tying the most effective resources to the hypothesis that suits them best or pairing an expert with a novice so that they can help the novice level up their abilities.

The following is an example of a skills matrix that might be used to assess a potential threat hunter. It is important to note that each organization is different, this is not meant to needs of every organization or team, but as a stepping stone in the right direction.

Example

Rating on a scale of 1-5

5 - Expert. - Highly experienced. Needs no help from others. A subject matter expert (SME).

4 - Proficient - Experienced. Can work alone with little help. Working toward expert.

3 - Mid-level - Some experience. Can perform on their own with occasional help needed.

2 - Basic - Limited knowledge. Requires significant help from others.

1 - Low - Little to no experience.

Threat Hunter Skills Matrix	Hunter 01	Hunter 02	Hunter 03								

General			
Report Writing	4		
Dashboard Creation	4		
Presentation Skills	5		

Network			
Network Foundations	5		
Network Architecture	5		
Network Segmentation	5		

Traffic Flow	5		
Subnetting & RFC 1918	5		

Infrastructure			
Routers	5		
Switches	5		
Firewalls	5		
Proxies	4		
IDS/IPS	4		
VPN	4		

Network Protocols			
TCP/IP Foundations	5		
HTTP	5		
SSL/TLS	5		
RDP	5		
FTP	5		
SSH	5		
ICMP	5		
DNS	5		

DNS Tunneling	5		
Packet Capture Analysis	5		
Wireshark	5		
Encrypted Traffic Analysis	3		
JA3	3		

Logs			
Syslog	5		
Audit Logs	4		
EMET Logs	4		
OS Event Logs	5		
Powershell	3		
Shimcache & Amcache	4		
Web Server	3		
Proxy	3		
Antivirus	5		
Bash History	4		

Operating Systems			
Windows	5		

Linux	4		
MacOS	4		
Unix	4		
Android	3		
iOS	4		
AIX	2		

Endpoint			
Process Relationships	5		
Scheduled Tasks	5		
Services	5		
Permissions	5		
Windows Registry	5		

Cloud			
Amazon AWS	4		
Microsoft Azure	3		
Google Cloud Platform	4		

General Security			

Access Control			
Multi-Factor Authentication			
Virtual Machines			
Container Security			
Social Engineering			
Phishing			
Physical Security			
Internet of Things (IoT)			
Industrial Control Systems (ICS)			

Offensive Security			
General Offensive Skills			
Vulnerability Assessment			
Penetration Testing			
Red Teaming			
Kali Linux			
Webshells			
Credential Dumpers			

Defensive Security			

Incident Response
Data Forensics
Memory Forensics

Threat Intelligence
MITRE ATT&CK
STIX Rules
General Threat Intelligence Platforms
Mandiant Advantage Threat Intelligence
ThreatConnect
IBM X-Force Threat Intelligence
Recorded Future Intelligence Platform

Malware
Malware Analysis
YARA Rules
Malware Sandboxing
Malware Reversing
Domain Generation Algorithms
Command & Control Infrastructures (C2)

Ransomware Families			

Security Information & Event Management (SIEM)			
General SIEM Experience			
Splunk			
QRadar			
NetWitness			

Security Orchestration Automation & Response (SOAR)			
General SOAR			
Playbook Creation			
Splunk Phantom			
Palo Alto Cortex			
Rapid7 InsightConnect			
IBM Resilient			

User & Entity Behavioral Analytics (UEBA)			
General UEBA Experience			

Resourcing

Small Organizations

Convincing management that utilizing resources that are already spread thin in order to begin a threat hunting program isn't easy to do, but just like the size of your team, start small. Don't think about hunting as something that requires dedicated team members, think about it in hours. Start by carving out a small number of hours for each analyst each week to spend hunting. As each analyst participates in a hunt ensure that they're documenting the hypothesis that they are working on, what things caught their attention, what they learned by exploring that hypothesis, and of course what findings, if any, there were while working on it.

Going back to management and saying "We've spent 16 hours hunting this week but haven't found anything" isn't going to get you more time to hunt. However, going back and saying "We tested four different hypothesis that led us to create two new alerts and one resolve one misconfiguration" will.

- Start small. 4-6 hours per analyst per week.
- Document your findings to show value.
- Grow the number of hours as proof of value is shown.

Large Organizations

Just because an organization is of a significant size doesn't mean that it's spoiled for resources. What it does mean is that it can sometimes be easier to move some of those resources around, test new ideas, or launch new projects. Ideally, an organization of any significant size should have 10-20% of its SOC staff dedicated to threat hunting. This number may sound significant, but as you conduct hunts and see the immense value that comes from them this number will absolutely make sense. The option of having dedicated hunters means that you can ensure the time spent by these individuals is focused on putting threat intelligence into action and that they aren't being distracted by the alerts and tasks assigned to a typical SOC or CIRT analyst.

- Dedicate between 10-20% of SOC or CIRT staff as threat hunters.

- Create clear lines of communication between hunters, the threat intelligence team, SOC/CIRT analysts, and incident responders.
- Document and escalate findings to management in order to show value of this specialized team and make the case for additional full time equivalents (FTEs) to expand the hunt team.

It is the experience of the authors of this framework that threat hunting is responsible for the detection of the types of data that leads to more declared incidents than by working alerts or incidents out of a queue. By its very nature threat hunting is focused on the discovery of activity that isn't being detected by security appliances, applications, or standard remediations. This leads to hunters encountering attacks or methods of persistence that require varied skill sets and the time to understand how best to handle the threat and create new mitigations to meet them. A dedicated and focused hunt team working side by side with analysts and incident responders is the most effective way to do this.

Skills Matrix

Preparation

"Data" is everything. Without data, there is nothing to investigate, nothing to hunt for. Reliability of the data determines how productive and efficient will be your hunt team. It won't be wrong to say Data Science is a key element of Threat Hunting. Therefore, it is important to discuss data, data reliability and data dictionary.

The Data

Threat hunting involves analyzing data from variety of sources to recognize unusual patterns. There is no standard on how much data will be needed or what data sources will be needed for specific threat hunt.

These logs would come from network activity and the data from operating systems of endpoints and applications. First, it is important to understand, based on the

operational environment, what fundamental data sources are available at your disposal. The data sources can be categorized as network, end points or security relevant. The security event data would come from:

1. Physically controlled areas: Data centers, Server Racks / Cabinets, or Control Centers have gates for access control, CCTV cameras, or heat sensors.
2. Networking devices: this would include network access control devices such as web proxies, firewalls and intrusion prevention systems, detective controls such as intrusion prevention systems.
3. Network traffic: packet capture
4. Operating system on End Points: Different end points such as servers, workstations, or Human Machine Interaces (HMIs) provide system events (operations performed by OS) and audit events.
5. Applications and Services: Customized or Commercial Off The Shelf (COTS) applications, services, Application Programming Interfaces (APIs) will provide data request and responses, usage information and other significant events.
6. Security software: Data from Antimalware software, and vulnerabilities management software

The information should be documented in detail with standardized metadata in a central repository. This metadata repository is also called as event data dictionary. It is important because different fields / attributes available in the event data could provide contextual information for data analysis and correlation.

Developing and Maintaining Data Dictionary

Threat hunting requires a thorough understanding of normal operations. That means, it is essential to know every single data source logged and collected for development of analytics

e.g. Security, Sysmon or PowerShell logs. Beyond log sources, team should also know the attributes behind every log data collected. Why?, data scientists or

analysts spend 80% of their time just finding, cleaning and organizing data. Threat hunting effort is no different. The threat hunter must have an easy way to discover, access and share the data.

"Data Dictionary" solves this problem. The Data Dictionary is a collection of names, definitions, and attributes about data elements that are being used or captured. Data dictionary helps avoides data inconsistencies, provides consistency in the collection and use of data, and enforces the use of data standardization. A data dictionary should become the go-to tool to understand everything about a data set and check data quality at a glance.

If you have recently initiated or kicked-off the Threat Hunting program or have no data governance team, it is likely that Data Dictionary doesn't exist within your organization. Creating Data Dictionary is not a small endeavor. Effort required to develop the data dictionary largely depends on the technology landscape of the organization, organizational processes and available human resources. Organizations may choose to develop it all at once (focused project) or gradually develop and improve this library during different security initiatives.

Specific contents in a data dictionary can vary. In general, these components are various types of metadata, providing information about data. When planning to create a data dictionary, it is important to consider all available data management resources, including databases and spreadsheets. Online templates are useful for creating this type of data dictionary . Dragos introduced "Collection Management Framework"[8] that provides guidance on keeping track of tools used and data being collected.

Initiate the development by assessing and documenting the tools implemented and configured in your organization. Start by listing the data sources at high-level and

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[8] Collection Management Frameworks – Looking Beyond Asset Inventories in Preparation for and Response to Cyber Threats

then collect more detailed information from each data source Following resources could be useful for development.

- Existing commercial security tools within your ecosystem (i.e EDR solutions) that collect data for you, your vendor should be providing data dictionaries for every security event.
- Open-Source Security Events Metadata (OSSEM)[9]. OSSEM defines and share a common data model to improve the data standardization and transformation of security event logs. It also allows you to define and share data structures and relationships identified in security events logs.
- MITRE CAR[10] provides the dictionary of data objects that may be monitored based on MITRE ATT&CK framework

Data Reliability

Let us focus on the use of data now. Threat hunter will use scientific methods, processes, algorithms and systems to extract knowledge and insights from noisy, structured and unstructured data, and apply knowledge from data across a broad range of application domains. Therefore, data reliability crucial. It is an aspect of data quality that defines how much data is complete and accurate. This improves the data trust. It eliminates the guesswork, gives accurate analysis and insights.

Reliable data is:

- Complete – datasets must contain all required information. It should not be limited to high value assets.
- Accurate – data must conform with reality.
- Timely – data must be accurate in a specific period.

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[9] https://github.com/OTRF/OSSEM

[10] https://car.mitre.org/

- Validated – data must have right values for the attributes.
- Consistent – data may get stored and transported to different applications, quality of data must be maintained.
- Unique – the data set shouldn't be recorded more than once.

Low reliability of the data can result in aggregations of incorrect data that can lead to wrong decisions that is, incomplete or incorrect hunt results.

Therefore, investing in data reliability consistently will yield faster and reliable threat hunts. It will allow the automation of detection, essential for effective security monitoring.

Mature security organizations likely have security data governance team to improve the reliability of the data required for security monitoring. However, that does not guarantee the data reliability. It is feasible that team runs into the issues such as coverage, missing data, missing standard naming conventions, parsing issues, and timestamp.

Therefore, it is essential that Data Governance and Threat Hunt teams work side by side, share the hunt objectives and findings. This feedback process will ensure the continuous improvement needed for improving data reliability.

In the absence of data governance team, Threat Hunt team should assess and improve data reliability.

Technology Stack

The event data generated by different data sources within the organization is continuous. The Size of an organization greatly influences the volume of data it generates. On any given day, a large organization can generate hundreds of gigabytes of log data. When dealing with that much data, there are some common issues. The automated data collection, storage and analytic tools is ideal while analyzing the large volume of data and correlating multiple data sources.

Log management systems allow log data collection, data retention, log indexing, reporting, and searching capabilities. Whereas, Security Incident and Event Management (SIEM) system is characterized by Security Event Management (SEM), Eecurity Information Management (SIM), and Security Event Correlation (SEC). SIEM automatically correlates, including all your log data, better than what humans can do alone. SIEM approaches log analysis with a security focus.

Organizations have finite resources. Therefore, organizations prioritize the log sources and data management. Threat hunter must be aware of what data has been automated and is made available at a centralized location (log management system) and what data must be collected and extracted manually.

Threat hunters use a variety of tools to support their methodologies. Tools can include the following:

- Log management system: this allows threat hunter to query, analyze and correlate large volume of data. Allows data analysis and correlation at scale.
- Advanced analytics and statistical analytics tools: If organization has not implemented log management or SIEM, open-source tools such as MongoDB or Redis tools could support ingestion and analysis of large volume of data. Although, feasible, this manual process would require the team to collect and load the data manually. This could be very time consuming as, the team must:
  - develop custom parsers for different log sources for data ingestion
  - develop custom queries for search and correlation of data
- Spreadsheets: This is well known and universally adopted tool for data analysis and statistical analysis. However, it is not optimal while handling large volume of data and correlation.

Threat Hunting Lab Environment

Having a lab or research environment available for hunters is a critical component of a effective threat hunting program. The OTHF Threat Hunting Process touches briefing on lab environments during the "Create Test Data" section of the process however in this section, we will cover some fantastic tools to help hunters build threat hunt lab environments of various scales.

Blue Cloud

BlueCloud is a collection of Terraform and Ansible scripts that enables users to deploy a cyber range within AWS or Azure.

GitHub Repo: https://github.com/iknowjason/BlueCloud#infrastructure-and-credentials

Documentation: https://blue.iknowjason.io/

OTHF Hunting Lab

The OTHF team has put together a collection of Vagrant files that enables users to build a small Microsoft Active Directory environment with a domain controller, member servers, and workstations with all endpoint logs being sent to a Splunk server.

OTHF Lab Credentials

Domain Administrator:

Username: Administrator

Password: !P@ssword123456

Domain: OTHF.local

Local Windows Credentials:

Username: vagrant

Password: vagrant

Splunk:

Username: Admin

Password: Vagrant123

Building

Prerequisites:

Virtual Box

Vagrant

vagrant plugin install vagrant-windows-domain

vagrant plugin install reload

vboxmanage list dhcpservers

vboxmanage dhcpserver remove --network="HostInterfaceNetworking-VirtualBox Host-Only Ethernet Adapter"

Build

Provision Domain Controller

- From a command prompt navigate to BuildDC directory and type “vagrant up”
- Once provisioned, log into the new VM with Username: Vagrant Password: vagrant
- Open PowerShell as Administrator and run InstallDomain_1.ps1 from c:\users\vagrant\desktop
- When completed, restart the domain controller
- Note: double check that Adapter 2 is on VirtualBox host-only ethernet adapter sometimes VBox will create multiple adapters.

- Log into the domain controller with username: othf\administrator password: !P@ssword123456
- Open PowerShell as Administrator and run InstallDHCP_2.ps1 from c:\users\vagrant\desktop, when prompted type Y
- At this point, you should have a Domain OTHF where the domain controller IP is 10.10.1.1 on Ethernet 2 (host only), a DNS record for dc1 for 10.10.1.1, and DHCP server serving up Ips in the 10.10.1.0/24 space

Provision Splunk

- From a command prompt navigate to Splunk directory and type “vagrant up”
- Note: double check that Adapter 2 is on VirtualBox host-only ethernet adapter sometimes VBox will create multiple adapters.
- When finished, log into the Splunk server using username: vagrant password: vagrant
- Configure the Splunk server w/ the IP address 10.10.1.3
- Open firefox, and navigate to http://127.0.0.1 :8000
- The splunk UI should appear, log in with username: admin password: Vagrant123

Provision Workstation/Server:

- From a command prompt navigate to Splunk directory and type “vagrant up”
- Note: double check that Adapter 2 is on VirtualBox host-only ethernet adapter sometimes VBox will create multiple adapters.
- When completed reboot the machine.
- Log in and navigate to c:\\users\\vagrant\\desktop\\ConfigAuditing.ps1 and run as administrator

Once all the components are built, you will have Sysmon and Windows Event Logs flowing to Splunk in the index “threathunt”

To search

- Open firefox, and navigate to http://127.0.0.1 :8000
- The splunk UI should appear, log in with username: admin password: Vagrant123
- Click on search and reporting
- Type in index=threathunt and look in the past 15 minutes to view logs

Operational

Threat Hunting requires a methodical approach. However, it is important to remember that -Threat Hunting is not a project (time bound activity). As attackers keep evolving, threat hunters should create new detection mechanisms and continuously refine existing ones to improve detections (i.e. reduce false positives and automate). With the OTHF, threat hunt teams can have a continuous improvement driven framework for threat hunting that is designed to scale to support even the largest organizations by acting as the driving force behind automated detections. This isn't the art of fiction. Over the years, the OTHF team has worked rigorously to create a platform agnostic threat hunting process and this framework and processes is the result of zeal for effective and efficient threat hunting that will integrate with automated detection processes such as Palantir' Automated Detection Strategy (ADS)[11] and applying lessons learned during incidents responded.

[11] https://github.com/palantir/alerting-detection-strategy-framework

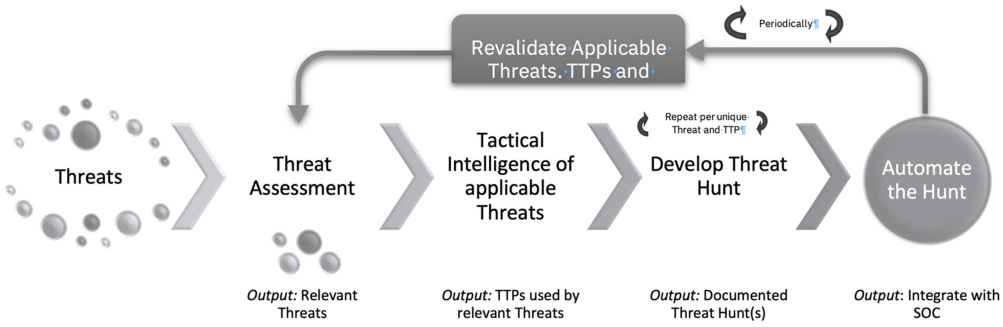

Figure 3: Threat Hunting Framework

At its core, the framework lays out simple steps:

1. Know the threats as applicable to your company and industry
2. Understand TTPs for applicable threats
3. Develop the Threat Hunt per unique TTP
4. Automate developed Hunts
5. Periodically revalidate the work – Threats, TTPs and Hunts.

Details below explain how Threat Hunter could benefit from those building blocks and elaborates the process of Threat Hunting.

Identifying Hunts

Every organization faces security risks, but the risks aren't the same for everyone. An attacker specifically targeting a hospitality organization, for example, will likely go after different assets than an attacker specifically targeting an electricity utilities company. Within the organization, targets may vary. An attack on the accounting department might target financial data or employees' personal information, while an attack on the engineering department might target intellectual property. Additionally, there are also threats that are opportunistic in nature that are not targeting a specific industry or organization but can pose as a significant risk.

This section of the OTHF is designed to help organizations identify and prioritize hunts to maximize the value of the threat hunting program.

Intelligence Driven

Much like with threat hunting, the OTHF is not meant to be a definite guide on cyber threat intelligence (CTI), but it is important for a threat hunting program to understand that CTI can be a major asset to identify and prioritize threat hunts.

CTI provides crucial support by providing detailed information on characteristics of previous attacks, common access vectors, and the techniques and procedures that adversaries employ. Threats are characterized by types of attackers, common points where an infection might occur, and the procedures attackers are likely to employ. Understanding the steps attacker may take, allows the threat hunter to define the potential clues of malicious behavior aligned with the attack stages.

While having a dedicated CTI team to help identify and prioritize activities for the threat hunting program is ideal, the OTHF will cover approaches that can be adapted by organizations of varying levels of maturity.

The OTHF focuses mostly on two types of threat intelligence:

- Strategic Threat Intelligence (STI) – High level analysis of adversary motivations, abilities, and associated targets. STI is not focused on the technical details of how an attack will happen but rather this intelligence will shed light on why adversaries attack and who they may target.

Tactical Threat Intelligence (TTI) – Detailed analysis of the TTPs associated with an adversary or malware family. TTI analysis may include multiple reports for adversary groups or malware families which describe the how an attack will happen through each of its various stages.

Strategic Threat Intelligence Sources

In more mature organizations, an internal or third-party CTI team should be leveraged for the latest intelligence on which adversaries are actively targeting or

most likely to target an organization and would be the underlying motivation for the attack.

If the threat hunting team has access to a dedicated CTI team, the threat hunt program should coordinate with the CTI team to receive regular updates on adversary activities and motivations. The threat hunting program should be able to identify the top threats to the organization at any given time through a relationship with the CTI team.

If an organization does not have a dedicated CTI team, threat hunting programs can leverage several free sources to gather STI data including a mapping adversary groups to targeted industries and motivations.

Electronic Transactions Development Agency

The Electronic Transactions Development Agency (ETDA) maintains a Threat Actor Encyclopedia containing numerous threat actor groups. Within each entry, users can find a description of the adversary, suspected country of origin, targeted sectors and countries, and motivation. Additionally, where applicable the ETDA populates a "Operations Performed" section detailing attacks that have been attributed to the adversary.

Every threat actor "card" can be downloaded as a PDF or JSON object.

ETDA Threat Actor Encyclopedia: https://apt.etda.or.th/cgi-bin/listgroups.cgi

APT group: FIN7

Names	FIN7 *(FireEye)* Gold Niagara *(SecureWorks)* Calcium *(Symantec)* Navigator *(Fox-IT)* ATK 32 *(Thales)* APT-C-11 *(Qihoo 360)* ITG14 *(IBM)* TAG-CR1 *(Recorded Future)*
Country	Russia
Motivation	Financial crime
First seen	2013
Description	FIN7 is a financially-motivated threat group that has primarily targeted the U.S. retail, restaurant, mid-2015. They often use point-of-sale malware. A portion of FIN7 was run out of a front compar FIN7 is sometimes referred to as Carbanak, Anunak, but these appear to be two groups using the and are therefore tracked separately. The reports about arrests made of the mastermind of Carbanak instead of FIN7. However, securit referring to this arrest for all FIN7 activities since.
Observed	Sectors: Casinos and Gambling, Construction, Education, Energy, Financial, Government, High-Tec Technology, Telecommunications, Transportation. Countries: Australia, France, Malta, UK, USA

Figure 4: ETDA Threat Intelligence on FIN7

The MITRE ATT&CK Groups

MITRE maintains a Groups page within the ATT&CK framework that provides an overview of adversary groups and the industries they frequently target. MITRE classifies a group as "sets of related intrusion activity that are tracked by a common name in the security community"[12]. While the level of STI gathered from MITRE Groups may not be as detailed or targeted as what a dedicated CTI team will produce, threat hunters can leverage the resources within MITRE Groups to identify which adversaries are associated with their organization's industry and check the references for attributed attacks against parent companies, subsidiaries, or geolocations.

MITRE ATT&CK Groups: https://attack.mitre.org/groups/

[12] https://attack.mitre.org/groups/

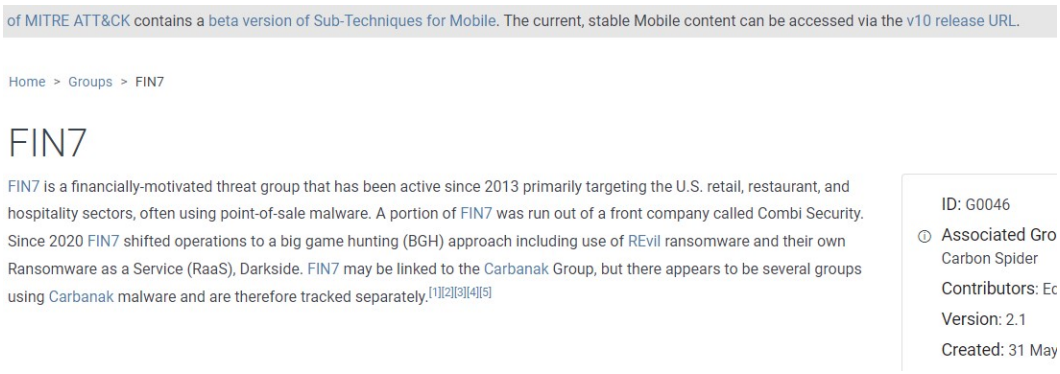

Figure 5: MITRE ATT&CK Threat information on FIN7

Other Sources

Secureworks Threat Profiles: https://www.secureworks.com/research/threat-profiles

Mandiant Advanced Persistent Threat Groups: https://www.mandiant.com/resources/apt-groups

Tactical Threat Intelligence

In more mature organizations, an internal or third-party CTI team should be leveraged for the latest intelligence on mapping adversaries and malware to specific tools, tactics, and procedures. If a dedicated CTI team is available to the threat hunting program, the CTI team should be consistently maintaining a TII resource and make it available to all threat hunters.

If an organization does not have a dedicated CTI team, threat hunting programs can leverage several free sources to gather TII to gather intelligence on the TTPs leveraged by various adversaries and malware.

The MITRE ATT&CK Tactics and Techniques

MITRE provides a comprehensive library of adversarial tactics and techniques. A globally accessible open-source knowledge base, it incorporates a detailed list of offensive tools and techniques that hunt teams can draw from when constructing

hypotheses. The framework also includes a detailed list of which data sources should be examined a specific technique in an environment.

For the techniques defined in MITRE ATT&CK framework has a “Data Sources” field in the reference box to the right which explains what Data Sources are recommended for the detection of the specific technique.

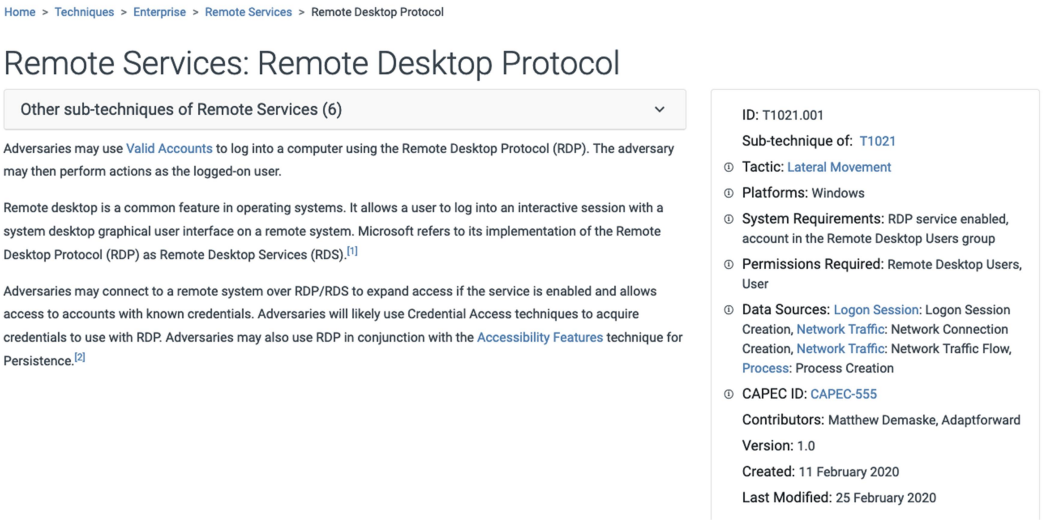

Figure 6: The MITRE ATT&CK Framework TTPs

MITRE also maintains an ATT&CK Software repository which details malware and tools used

MITRE provides a comprehensive library of adversarial tactics and techniques. A globally accessible open-source knowledge base, it incorporates a detailed list of offensive tools and techniques that hunt teams can draw from when constructing hypotheses. The framework also includes a detailed list of which data sources should be examined a specific technique in an environment.

For the techniques defined in MITRE ATT&CK framework has a “Data Sources” field in the reference box to the right which explains what Data Sources are recommended for the detection of the specific technique.

Home > Software > Carbanak

Carbanak

Carbanak is a full-featured, remote backdoor used by a group of the same name (Carbanak). It is intended for espionage, data exfiltration, and providing remote access to infected machines. [1] [2]

ID: S0030
Associated Soft
Type: MALWARE
Platforms: Windo
Version: 1.1
Created: 31 May
Last Modified: 0

Electronic Transactions Development Agency

The Electronic Transactions Development Agency (ETDA) maintains a Threat Actor Encyclopedia containing numerous threat actor groups. Within each entry, a "Tools used" section is populated with tools that have been associated with the adversary. Each tool within the ETDA encyclopedia contains information describing tools capabilities, uses, and links to other reports associated with the tool.

Every tool "card" can be downloaded as a JSON object.

ETDA Threat Actor Encyclopedia: https://apt.etda.or.th/cgi-bin/listgroups.cgi

Tool: Carbanak

Names	Carbanak Anunak Sekur
Category	Malware
Type	Reconnaissance, Backdoor
Description	(Kaspersky) Carbanak is a backdoor used by the attackers to compromise the victim's machine once the exploit, either phishing email or exploit kit, successfully executes its payload. This section provides a functional analysis of Carbanak' Carbanak copies itself into "%system32%\com" with the name "svchost.exe" with the file attributes: system, hidden a The original file created by the exploit payload is then deleted. To ensure that Carbanak has autorun privileges the malware creates a new service. The naming syntax is "Sys" where is any existing service randomly chosen, with the first character deleted. For example, if the existing service´s name is the visible name is "Asp.net state service", the service created by the malware would be "aspnetSys" with a visible nar state service". Before creating the malicious service, Carbanak determines if either the avp.exe or avpui.exe processes (components Internet Security) is running. If found on the target system, Carbanak will try to exploit a known vulnerability in Windo Windows Server 2003, Windows Vista, Windows Server 2008, Windows 7, Windows 8, and Windows Server 2012, CVE for local privilege escalation. We believe this is not relevant and that the attackers adapt their tools to the victim´s def
Information	<https://media.kasperskycontenthub.com/wp-content/uploads/sites/43/2018/03/08064518/Carbanak_APT_eng.pdf> <https://www.fireeye.com/blog/threat-research/2017/06/behind-the-carbanak-backdoor.html> <https://www.fireeye.com/blog/threat-research/2019/04/carbanak-week-part-one-a-rare-occurrence.html> <https://www.fox-it.com/en/wp-content/uploads/sites/11/Anunak_APT-against-financial-institutions2.pdf> <https://documents.trendmicro.com/assets/white_papers/wp-cashing-in-on-atm-malware.pdf>

Figure 7: ETDA Tactical Intelligence

Threat Assessment

Threat assessment is a proactive activity to help an organization understand their specific risks by gaining insight into what adversaries may be targeting them and how the attack may happen. Threat assessments, blend data from STI and TTI and through this exercise a threat hunting program can identifying hunts that are relevant to an organization and can have a positive impact on the organization's level of risk.

Threat assessments should take a methodical approach and depending the resources available to the threat hunting program, portions of a threat assessment may be based on assumptions or best guesses. As a threat hunting program matures, the accuracy of the threat assessment should improve based on improved STI, TTI, and understanding of the organization.

- First step is to use the available resources to gather STI to identify threats that are applicable to your organization. Understand these adversaries and their evolving methodologies.
- Research and understand the identified adversaries. Analyze the threat groups' motivations, to assist you in crafting a narrative of threats to your organization
- Based on the motivations and methodologies of the adversaries, understand the basic level of potential impact to the organization. This section is not meant to include a full impact assessment but rather gives hunters and opportunity to prioritize hunts based the severity of different style of attacks.
- Research and understand the tools, techniques, and procedures associated with the adversary to build a narrative about how each adversary carries out an attack
- Based on the capabilities and tools/techniques of adversaries, combined with your knowledge of security controls determine the likelihood of the attack.

Most organizations have finite resources and budget. It may be practically impossible to address every identified threat group based on available resources. Prioritization is key. Threat hunting programs can leverage the threat assessment process to identify hunts that will provide the most value to the organization.

Figure 8: Threat Assessment Process

MITRE Navigator

MITRE Navigator is a free tool that enables users to efficiently use the data within the ATT&CK framework. Navigator enables users to create layers upon the ATT&CK matrix and automatically annotate techniques that are applicable to the defined layer.

Navigator allows threat hunters to quickly query the ATT&CK data set to highlight associated tactics and techniques associated with group, software, data sources, and mitigations.

Figure 9: Threat Assessment using MITRE Navigator

Vulnerability and Exploit Data Driven

According to NIST, a vulnerability is a weakness in a system, system security procedures, internal controls, or implementation that could be exploited or triggered by a threat[13].

Vulnerabilities are just a reality that all security teams must accept. Every year, a vast number of new vulnerabilities are discovered and made public, and organizations must constantly assess and patch vulnerabilities. Patch management has continually been a challenge for organizations and within the time where a vulnerability is released and a patch is successfully applied, organizations are at risk from additional threats. During this window of vulnerability, threat hunting teams can provide some risk mitigation coverage by executing threat hunts for evidence that the vulnerability has been used as part of an attack.

Typically, a vulnerability disclosure does not contain enough information for threat hunters to successfully execute a hunt for an associated attack. There is a significant difference between something being vulnerable and something being exploitable. Exploits are pieces of code or sequences of instructions that take advantage of a vulnerability to cause an unintended behavior, gain unauthorized access, or execute arbitrary additional commands.

While a vulnerability details a theoretical way to execute an attack against exploits provide a direct path for an adversary to take advantage of a vulnerability in an attack. To help threat hunting teams identify and prioritize threat hunts associated with vulnerabilities, the OTHF encourages threat hunting programs to implement a similar triage process:

Figure 10: Vulnerabilities and Exploits Driven Hunts

- Vulnerability – A vulnerability is released

[13] https://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.1800-17.pdf

- Applicable to Org – Is the vulnerability associated with software, hardware, or other system that is used within the organization?
- Exploitable – Has there been an exploit released or has it been exploited by an adversary in the wild?
- Exploitability – How difficult is exploitation?
  - Is the vulnerability associated with software or systems that are publicly available?
  - Does it require preexisting physical, network, or authentication access to be successful?
  - Are there existing security controls that mitigate the exploit?
- Impact – What is the level of impact to the organization if an attacker successfully exploits the vulnerability?
- Hunt

Vulnerability and Exploit Data Sources

Exploit DB - project maintained by Offensive Security which is a collection of public exploits and vulnerable software.

https://www.exploit-db.com/

Rapid7 Vulnerability and Exploit Database – Repository of vetted software exploits and exploitable vulnerabilities.

https://www.rapid7.com/db/

CXSecurity – web-based application containing the latest exploits for local and remote vulnerabilities.

https://cxsecurity.com/exploit/

Attack Surface Driven

NIST defines an attack surface as "The set of points on the boundary of a system, a system element, or an environment where an attacker can try to enter, cause an effect on, or extract data from, that system, system element, or environment."[14]. Attack surface discovery (ASD) is a continuous process aimed towards discovering, categorizing, and evaluating the security of an organization's cyber assets. Where ASD differs from asset or vulnerability management is that ASD can be considered the aggregate of assets, vulnerabilities, mitigations, and controls to present an organization with a contextualized view of how areas within the network that an attacker could be successful.

Threat hunters can leverage ADS to identify and prioritize hunts for threats that are directly associated with the available attack surface of an organization. Leveraging ASD data to identify hunts, ensures that hunters are focused on threats that are most likely to be successful against their organization.

In the paper, "A Threat-Driven Approach to Cyber Security" [15] M. Muckin and S. Fitch propose a relational model between threats, assets, and controls. Through this model, Muckin and Fitch demonstrate that adversaries rarely directly access targeted cyber assets, instead they interact with and circumvent other components of a system to obtain their objectives. Muckin and Fitch go onto state that given an indirect relationship between adversaries and targeted assets, "controls must be selected and implemented to address threats and attack vectors" where a control is a direct response against relevant threats and attack vectors that exist within a given system or application.

Threat hunters can leverage threat intelligence as an input into a Threats-Assets-Controls Relational Model to identify potential areas of exposure and attack

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[14] https://doi.org/10.6028/NIST.SP.800-171r2

[15] https://www.lockheedmartin.com/content/dam/lockheed-martin/rms/documents/cyber/LM-White-Paper-Threat-Driven-Approach.pdf

vectors are highlighted which can drive identification of relevant hunts for a particular system or application.

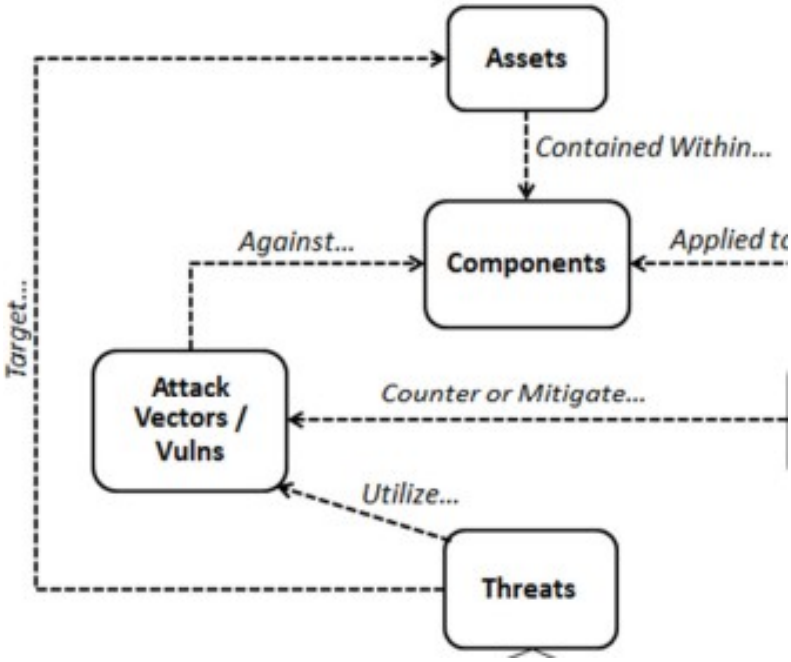

Figure 11: Muckin, Fitch Threats, Assets and Controls Relationship Model

Mission Driven

The delivery of the core operations while maintaining data security of those operations can be considered the missions of the organization. Outside of using threat intelligence to identify threat hunts, threat hunt programs may also choose to perform threat hunts based on ensuring mission assurance by focusing threat hunting efforts to detecting adversaries as they attempt to compromise mission relevant systems, services, users, protocols, devices, networks, processes, or data (cyber assets).

To fully understand and reduce the risk of impacting core missions, threat hunters must execute mission mapping and threat modeling exercises to identifying underlying cyber assets that enable the organization's missions.

The idea behind mission driven threat hunting is based upon K. Jabbour and S. Muccio, "The Science of Mission Assurance,[16]" where a four-step process is outlined for cyber mission assurance.

1. Develop and prioritize a list of mission essential functions
2. Mission mapping to identifying all dependencies a mission has on cyberspace
3. Identify vulnerable assets
4. Analyze risks and mitigate.

For mission driven threat hunting, hunters should take a similar approach:

1. Identify and prioritize core operations
2. Perform mission mapping to identify all mission dependent systems, services, and data
3. Perform a threat model of dependent systems, services, and data
4. Identify and prioritize hunts to detect identified threats for identified mission dependent systems, services, and data

The value of mission driven threat hunting is that hunters are prioritizing hunts based on a deeper understanding of what cyber assets are supporting missions and how an attack on them impacts the overall risk to the organization.

Mission Mapping

It is not uncommon for threat hunters or even the IT administrators to not fully understand all of the dependencies and interconnections of cyber assets that enable missions. Mission mapping aims to address this issue by actively building

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[16] K. Jabbour and S. Muccio, "The Science of Mission Assurance," Journal of Strategic Security, vol. 4, no. 2, pp. 61–74, 2011.

understanding of all of the complex relationships between cyber assets and their relation to missions.

There are various methods to perform mission mapping, but the methods drawn from J. Guion and M. Reith's "Cyber Terrain Mission Mapping: Tools and Methodologies" including Functional Mission Analysis, Crown Jewels Analysis, Ontology Modeling, and Impact Dependency Graph were all specifically designed for use by cybersecurity personnel to identify cyber key terrain.

It should be noted that some of the aforementioned mission mapping methodologies are highly effective but require a significant amount of effort and supporting software to build out and maintain. As threat hunting organizations mature, they may opt to implement one of the methods from "Cyber Terrain Mission Mapping: Tools and Methodologies" that factor in quantitative data.

For the purposes of the OTHF, the framework will focus on Ontology Modeling which leverages an entity-relationship-attribute (ERA) diagram to create an easy-to-understand mission map modeling the relationships between missions, users, capabilities, and assets.

It is not a requirement for any threat hunting program to implement a defined mission mapping standard, some organizations may opt to identify key missions and model their cyber asset dependencies through a tree graph, with the mission at the top and connecting dependent systems, software, users, networks, and physical infrastructure in a hierarchal manner.

Ontology Modeling

In the paper, "CAMUS: Automatically Mapping Cyber Assets to Missions and Users"[17], Goodall, D'Amico, and Kopylec from Applied Visions Inc outline how they

[17] https://securedecisions.com/wp-content/uploads/2011/06/Camus-Automatically-Mapping-Cyber-Assets-to-Missions-and-Users.pdf

translated ERAs into a ontology models for automated mission mapping using a custom tool named CAMUS.

The resulting mission mapping models leveraging the ERA approach results in a nodal graph where relationships are defined as “uses”, “depends on”, and “requires”. Through this approach threat hunters are able to traverse the graph and ask, “What cyber assets are needed to execute my mission”, or the bottom-up, “what missions are impacted by the loss of this system”[18].

Example of Ontology Model

In this simple example, we demonstrate an organization who has a core business component (mission) of “Receiving Orders”. User the ERA approach, threat hunters can identify and build threat hunts around proactively identify threats that would impact the cyber assets that the support Receiving Orders mission. Threat hunters may need to fuse vulnerability and attack service data with the ontology model to design a threat hunt for applicable threats for the identified cyber asset.

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[18] L. Buchanan, M. Larkin, and A. D’Amico, “Mission Assurance Proof-of-Concept: Mapping Dependencies

among Cyber Assets, Missions, and Users,” in IEEE International Conference on Technologies for Homeland Security (HST), 2012, pp. 298–304.

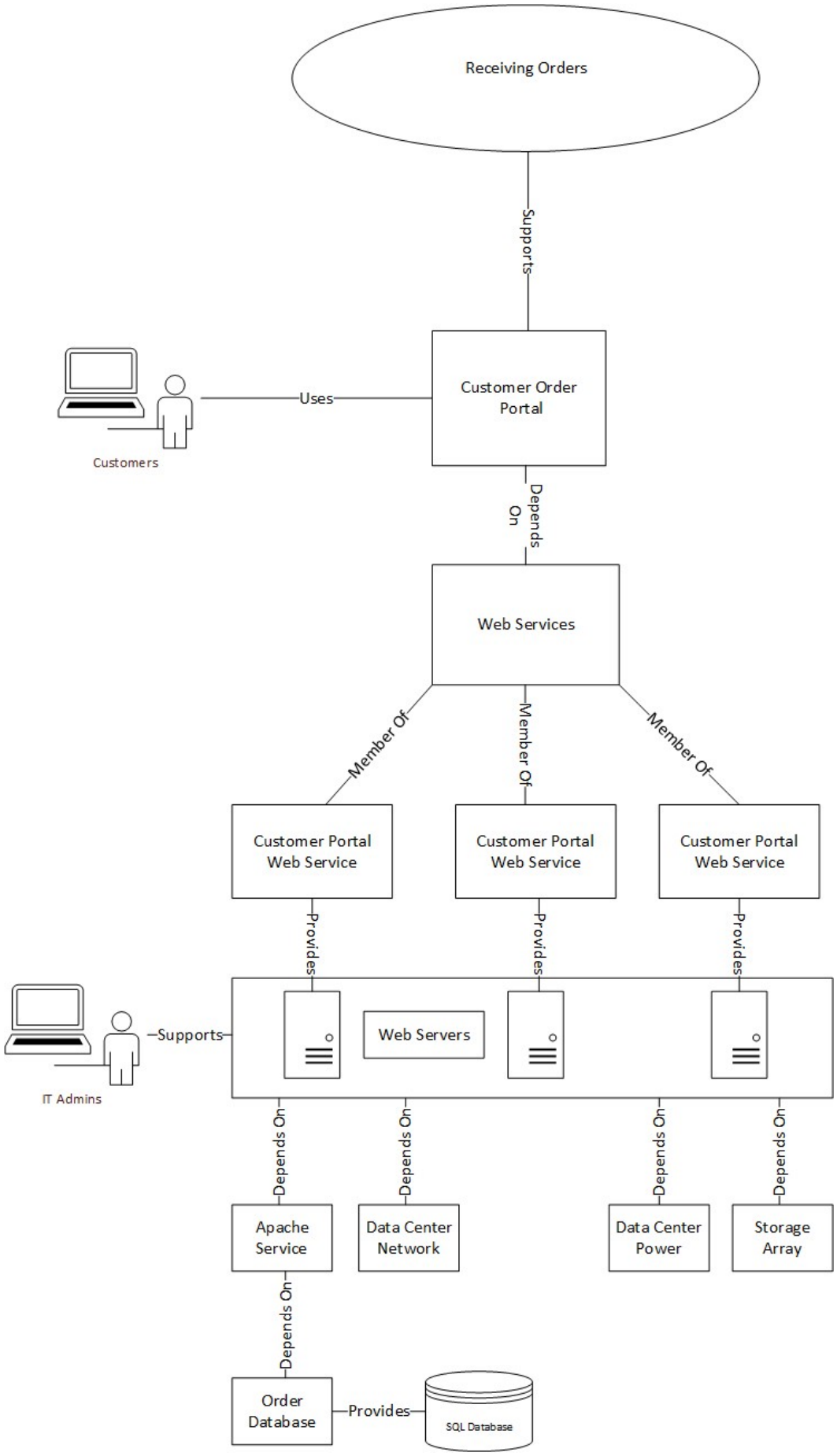
Receiving Orders
Supports
Customer Order Portal
Uses
Customers
Depends On
Web Services
Member Of
Member Of
Member Of
Customer Portal Web Service
Customer Portal Web Service
Customer Portal Web Service
Provides
Provides
Provides
Supports
IT Admins
Web Servers
Depends On
Depends On
Depends On
Depends On
Apache Service
Data Center Network
Data Center Power
Storage Array
Depends On
Order Database
Provides
SQL Database

Figure 12: Ontology Model Example

Observation Driven

As hunters get access to data, they may observe new trends, patterns in user or system behavior, or identify pieces of data that seem like anomalies compared to current and historical knowledge of the datasets. These observations can be a valuable driver in developing new threat hunts and provide an opportunity for threat hunters to leverage their unique understanding of the environment along with their creativity to identify threat hunts unique to their organization.

While observations may be obtained through unstructured mechanisms, hunters should use their observations to formulate a structure hunt.

The following process is meant to demonstrate how observations can drive a threat hunt.

1. While performing research within the network connected process data set, a member of the hunt team notices a process named “certutil.exe” making a network connection to an IP address 192.168.1.1
2. The hunter has never observed “certutil.exe” within the network connected processes data set.
3. The hunter performs a historical search for “certutil.exe” within the network connected process data and determines that this event is not an anomaly and occurs regularly within the environment.
4. The hunter does some research about why certutil.exe would establish a network connection for legitimate and malicious reasons.
5. Triaging the current and historical events, the hunter determines that this certutil.exe activity is legitimate

Hunter creates a hypothesis to hunt for malicious network connected certutil.exe events.

Threat Hunting Process

One of the most important elements to implement when operationalizing a threat hunting program is structure. Structure ensure that hunters remain task-driven, adhere to well-defined standards, and focused on activities that bring value to the organization. Without structure, hunt teams' risk executing hunts within a disorganized and disjointed environment which creates an extremely difficult situation to demonstrate the value of threat hunting or track improvements.

In terms of threat hunting structure, a well-defined threat hunting process is critical for setting up the threat hunting program for success and can prevent inefficient or ineffective hunts from devaluing the threat hunting program. The threat hunt process should be considered the authoritative resource for design, documentation, and quality standards for threat hunts.

It is important to note that there are various different threat hunting processes available, the OTHF team has developed a threat hunting process for everyone to use but organizations may choose to pick a different one like the TaHiTI process.

OTHF Hunting Process

Figure 13: OTHF - Threat Hunting Process

The OTHF process shows the high-level building blocks of Threat Hunting. The process should be applied for each unique threat and TTP identified. Each Threat Hunt should be defined and executed as a project with clear scope in mind aka Threat Hunting goal.

Figure 11: Detailed Threat Hunting Process- provides a detailed project overview and workflow. We explain the process in the text below.

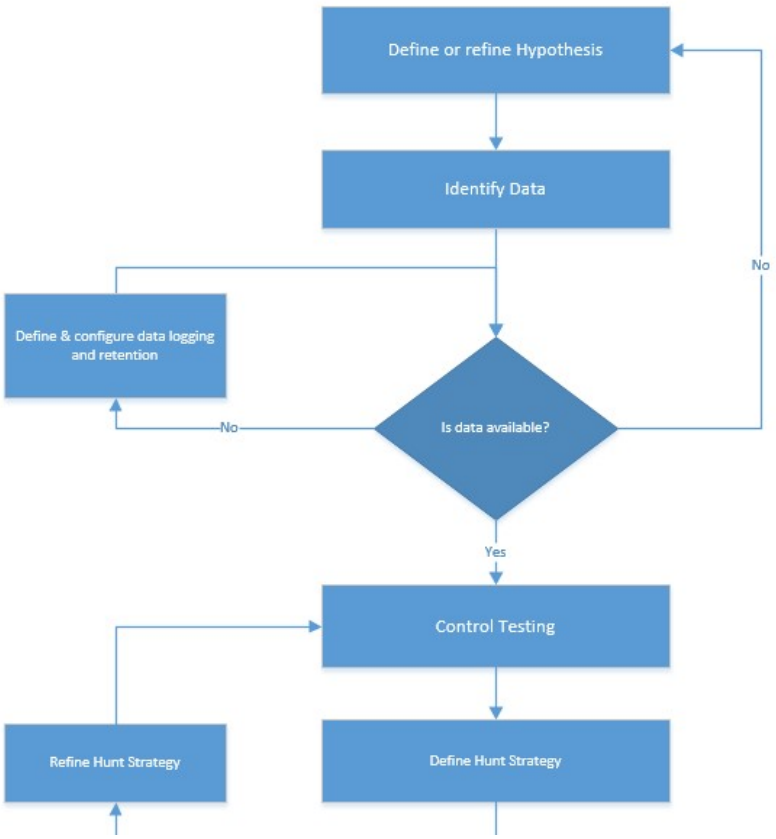

Figure 14: Detailed Threat Hunting Process

Define a Threat Hunt Goal

"If you don't know where you're going, any road will get you there."[19]

Having direction is very important in threat hunting. Not having direction, a goal, or not knowing where your hunt is going, it's all the same. You go nowhere. You can never get "there," because you don't really have a destination. Without direction, without a goal, threat hunts will suffer to determine success and risk being ineffective.

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[19] Quote by Lewis Carroll

Rather than generally searching for various types of threats, threat hunter should start by defining a specific, narrowly focused goal. The goal can be created based on any hunt identification methods listed in the Identifying Hunts section of the OTHF as well as any additional methods not listed however, threat hunting programs should define standards and best practices for goal development.

SMART Goals

SMART is a widely accepted criteria for individuals and organizations to set goals and objectives. SMART is an acronym that stands for specific, measurable, achievable, relevant and time-based.

Specific - Goal should be well-defined, clear, with unambiguous intentions

Goals that are specific have a significantly greater likelihood of being accomplished and a popular approach to designing a specific goal is to incorporate answers to the popular "W" questions.

Who – Consider who is required to accomplish the goal? Who will be responsible for executing and a dependency for success?

What – What exactly are you trying to accomplish? Details matter and it pays to be hyper focused when goal setting.

Where – Location specific details may not always be relevant to a goal but if there is a location or trigger that is relevant to the goal, it should be stated.

Why – Why are you trying to accomplish this goal? Why is it relevant to the organization? How does it incorporate with the organizations overall mission statement, goals, and objectives?

Measurable – Progress towards accomplishing the goal should be easily determined through defining specific criteria for measuring success.

Goals should have criteria for measuring progress and success. If there are no metrics defined than how will you determine if you've accomplished your goal or how close to completion are you?

Achievable – The goal should be attainable and not impossible to accomplish.

Goals are meant to enable progress not to discourage it. When setting goals, ensure that they are attainable and there are no major roadblocks like the lack of skills or tools to accomplish the goals.

Relevant – The goal should align with the broader goals and mission statement of the organization

Goal relevance refers focusing on something that makes sense within the scope of the organization's vision and mission. A goal that is designed to address an issue that is not relevant to the organization is not adding value.

Time-Based – The goal should be bound by a timeframe including a target date for completion.

The best goals in the world can be ruined through inaction therefore including time elements such as deadlines or intervals adds layers of accountability and urgency increasing the likelihood of success. Additionally, including Time-Based along with Measurable criteria within a goal can help you define what should be achieved at throughout the goal's lifespan.

Develop Hypothesis

Hypothesis is a testable statement about the proposed explanation for some observed phenomenon[20]. The foundations of a strong threat hunt hypothesis are relevance and testability. Relevance has been already explained above, it means how does the hypothesis relate to organizational needs, current industry trends, and available data sources. Testability means that the data and tools available would provide some chance of finding what the threat hunter is looking for within the hypothesis. That means, a good hypothesis is a question that helps you identify threats, gain information about your environment, or prove your hypothesis

[20] https://whatis.techtarget.com/definition/hypothesis

wrong or right. Not all these goals need to be met, however, hypothesis should always have a conclusion, whether it is proven right or wrong[21].

As Paul C. Price, Rajiv Jhangiani, I-Chant A. Chiang, Dana C. Leighton, and Carrie Cuttler detail in their work "Developing a Hypothesis", hypotheses always have an if-then relationship so threat hunters can structure their hypothesis with an if-then format to ensure they are crafting a craft a testable and measurable hypothesis.

Additionally, threat hunters can implement a "If..then" or "Given, When, Then" notation to their hypothesis to help ensure that it contains the core components of a strong hypothesis.

Given When-Then

Developed by Daniel Terhorst-North and Chris Matts as part of Behavior-Driven Development (BDD)[22], Given-When-Then is a notation style of representing unit tests.

Given-When-Then instructs users to break tests down to three sections:

- Given is meant to describe the context of the scenario or pre-conditions of the test.
- When is the triggering event or condition to test
- Then describes the resulting outcomes or changes you expect due to the specified behavior.

Within threat hunting, the given-when-then framework ensures that hunts are designed with testability and context to drive specifics.

Example

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[21] https://www.cybereason.com/blog/how-to-generate-a-hypothesis-for-a-threat-hunt-techniques

[22] https://martinfowler.com/bliki/GivenWhenThen.html#footnote-ivan

Given a Microsoft Exchange CAS is vulnerable to CVE-2021-26855 & CVE-2021-27065, **when** a remote adversary leverages the ProxyLogon RCE module within Metasploit to establish

Validate Data

Leveraging the knowledge gained through generating signal data, threat hunter should validate that the requisite data is available (logged and retained) and accessible to the threat hunt team to conduct searches. Better data quality leads to better decision making. Therefore, Threat Hunter should:

1. Document what data is needed: Identify what data is required to test the hypothesis. If you don't know where to start, as explained above, MITRE ATT&CK Framework provides a starting point by identifying data sources relevant to the techniques. Your Threat Intelligence team may offer you greater depth of details on techniques and data sources required based on their analysis and research.

2. Identify what is available: The data availability really means that quality data is available. Quality of data is essential in getting good and consistent results. The quality of the data should be validated based on following criteria:

    1. Availability: The environment may not be setup to provide you the data you need to conduct the hunt. If the data is not captured or logged and retained, Threat Hunt team should coordinate to get the data required for analysis.

    2. Completeness: The systems and tools may be configured to capture the data needed for threat hunt. However, the environment may not be configured consistently to provide required data e.g. data may be available on 50% of the end points – would hamper the quality of analysis and decision derived. Therefore, Threat Hunter must determine the minimum criteria to proceed and adjust.

3. Consistency: A data item(s) should be consistent in its content and format. If data isn't consistent, different groups may operate under different assumptions and skew the decisions.

4. Retention: Also referred as timeliness of the data. Data should get recorded as soon after the real-world event as possible. Data that reflects events that happened more recently are more likely to reflect the current reality. Data retention rules established in the organization can severely impact the ability to conduct effective hunts.

If Threat Hunt team identifies any quality gaps explained above, the project has already identified security gap. Threat Hunter can report these findings to fix data availability or refine the hypothesis to work with available datasets.

Roberto Rodriguez provides a fantastic overview of the importance of data validation in terms of threat hunting operations in his blog, "Ready to hunt, First, Show me your data!" [23]. In his blogpost, Rodriguez states "if data needed for a hunting engagement does not meet specific requirements defined by the hunt team, then the data is not considered quality data" meaning that all the data in the world will not necessarily advance threat hunting operations if it is not properly curated to ensure the highest data quality.

Before an organization can begin an effort to ensure that that threat hunting is using high quality data, organizations must first define a mechanism to measure data quality. Organizations have various options when choosing a strategy to measure data quality one example of a well-define data quality management solution is the DoD Total Data Quality Management.

Once an organization has established criteria and a measurement function to evaluate the quality of their data, they should implement a well-define data modeling strategy to provide specific guidelines regarding data modeling so as

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[23] Ready to hunt? First, Show me your data! - https://posts.specterops.io/ready-to-hunt-first-show-me-your-data-a642c6b170d6

new data is created, it adheres to a standard which produces high quality data. One such approach is the Common Information Model (CIM).

DOD Total Data Quality Management (TDQM)

Built upon existing total quality management approaches, DoD's TQDM process was designed as a process to support database migrations and promote the adoption of data standards amongst databases throughout the DoD. Through the TQDM process, the DoD has created a list of characteristics that threat hunt teams can use to quantify the quality of their data.

Characteristic	Description	Example Metric
Accuracy	Accurate data is free of errors and that can be used as a reliable source of information. Additionally, a qualitative assessment exists where fewer errors results in a higher assessment.	Percent of stored values that are correct when evaluated against the actual value. Example, Species=Cat when the subject is a cat.
Completeness	The degree to which values present in the expected fields.	Measurement of the number of fields that contain data vs the total number of fields.
Consistency	The measurement of variance a set of data adheres to a defined set of constraints	Percentage of values that match in type and structure across tables, files, and records.
Timeliness	The speed in which values are up to date within a data set.	Percentage of entire data set that is available within a specified time frame.
Uniqueness	The measure of the variance within the records of a dataset.	Perfect of database records having a unique primary key
Validity	The level of to which values are aligned with a defined	Percentage of values within a dataset that adhere to their allowed values specified by their

	classification and domain.	domain/classification.

Table 1: DoD Core Set of Data Quality[24]

Common Information Model

Common Information Model (CIM) standard is a project maintained by DMTF that defines how information systems, networks, applications, and services are managed while allowing for extensions through third party vendors.

The CIM standard includes a management schema, a specification, and a metamodel.

Management Schema – Structured into the distinct components: core model, common model, and extension schemas, the management schema supplies a well-defined framework of interrelated systems and their properties and associations.

Specification – Enables integrations with other management systems by providing definitions and syntax specifications for various systems to communication using a common domain.

Metamodel – Defines expressions for common elements that must be clearly presented to management applications (for example, classes, properties, methods, and associations).

A practical application of a common information model for threat hunting can be found with Splunk's Common Information Model. While Splunk's CIM is designing within the Splunk platform, the underlying concepts to implement data normalization and validation can be applied across various data types and platforms.

Create Test Data

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24 http://mitiq.mit.edu/ICIQ/Documents/IQ%20Conference%201996/Papers/DODGuidelinesonDataQualityManagement.pdf

This step refers to the process of creating test data based on the techniques adopted by the adversaries. Generating test data that is a direct result of the targeted technique used by adversaries is a critical step in validating that the hypothesis is accurate and requisite data is available. It is recommended to spin up a lab environment before to test these configurations, scripts, or subscriptions before finalizing the hunt for production deployment.

While recreating adversary operations with full featured offensive toolsets and command control infrastructure would be ideal for creating test data, several open-source tools exist that can help threat hunters generate signal data through actions associated with adversary techniques.

As the threat hunting team gains efficiency, team may lose valuable time orchestrating the test data. To overcome this inefficiency, organizations must expand the charter of management and development of test data to improve automation. This concept is well known as data-driven testing. The Red Canary team has maintained an open-source detection testing framework called Atomic Red Team[25]. It is a library of tests mapped to the MITRE ATT&CK® framework. Security teams can use it to reproducibly test the environments. As explained above, MITRE ATT&CK framework is a taxonomy of threats that attempts to describe the many techniques that an adversary might use when attacking an organization. In that context, Atomic Red Team can be referred as a collection of tests for emulating those adversary techniques.

As threat hunting and detection methods mature, organization should consider leveraging red team services to generate signal data for more advance TTPs.

Threat hunters need to analyze the data sources to prove or disprove a given hypothesis using multiple forms of evidence. Hunters should also document where the data comes from, ensuring that sources are both contextualized and consistent.

Define Hunt Strategy

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[25] Atomic Red Team - https://github.com/redcanaryco/atomic-red-team

In this stage threat hunters should design the conditions to target within the identified data source to identify adversary activity quickly and accurately. Threat hunters should use this stage to establish a baseline of what is normal for the given activities they are analyzing within the environment and should have a good understanding of what data patterns are present within the targeted data sources. Threat hunters should compare benign entries versus the signal data to understand the differences to target, so the hunt activity is hyper focused on only on adversary activity. A well-designed strategy can reduce false-positives and increase the hunt efficiency.

Validate the Hunt

The validation stage of the framework is a chance for the hunter to test their hunt strategy across a large set of data and may require a iterative process to ensure a threat hunt is ready for production.

Hunt validation requires the hunter to execute the hunt against data over time incorporating as much historical data as possible to test the hunt's signal-to-noise ratio[26]. As results of the hunt are received the hunter should evaluate the data and tune the conditions of the hunt to eliminate false positives or modify the hunt strategy as needed.

Figure 15: Iterative process of Hunt Validation over range of historical data

Document Findings

The final step is to ensure the goal, hypothesis, TTPs, and searches are methodically documented.

"If it isn't written down, then there is no evidence that it did or did not occur."

Documentation encourages knowledge sharing, which empowers your hunt team to understand the fundamentals of what data a hunt returned and whether it was

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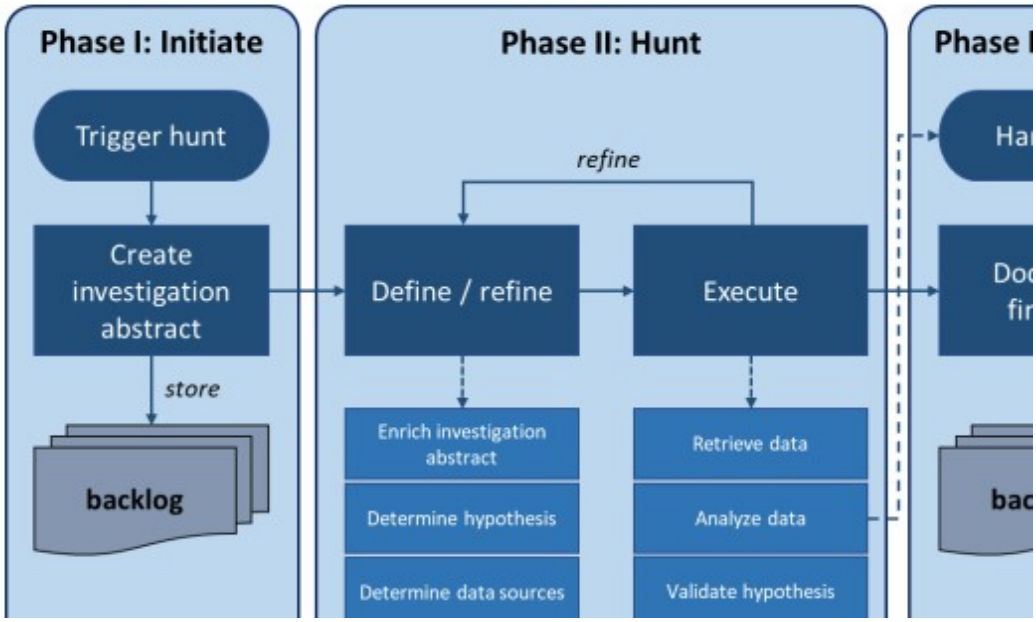
[26] https://en.wikipedia.org/wiki/Signal-to-noise_ratio

successful. Without documentation, threat hunting organizations will lack cohesion, become inefficient, and ineffective.

At the conclusion of every hunt, the hunter should document the date and time of the hunt and any all findings. Findings can be interesting observations, missing data, false positives, true positives, policy violations, or other data that helps hunters better understand their environments.

TaHiTI Hunting Process

https://www.betaalvereniging.nl/en/safety/tahiti/



Hunt Tempo

Threat hunts could be triggered by different security initiatives such as:

- New threat intelligence data – e.g. new threat actor, updates to the TTPs from known threat actor(s).
- Cybersecurity Incidents: findings from cybersecurity incidents or lessons learned

- Vulnerabilities reported after red team exercises / penetration testing
- Findings from tabletop exercises: tabletop exercises are excellent way to explore some process and data deficiencies for cybersecurity incident investigations.
- Other threat hunts: Threat hunt may result in findings that may trigger additional hunting projects.
- Identification and analysis of Crown jewels: The crown jewels could be critical processes, assets, or data, if compromised; may result in severe consequences.
- Threat modeling: Threat modeling is process that allows organizations to identify, enumerate and prioritize the threats based on the absence of security controls for the system.
- Regulatory requirements: new or changes in regulatory requirements may influence the need for new hunts. E.g. Changes in detection and reporting regulatory requirements could provide feed in hunt backlog.

It is important to keep the backlog of threat hunt ideas so that team can prioritize and schedule.

Prioritization

With finite resources within the team, it is essential to prioritize the hunts. The prioritization should depend combination on factors as :

1. The TaHiTI[27] (**T**argeted **H**unting **i**ntegrating **T**hreat **I**ntelligence) is a threat hunting methodology that focuses on the top 3 layers of the pyramid of pain – TTPs, Tools, and Network / Host Artifacts. The hunts based on the lower three layers are based on the information received from the past attacks and campaigns – e.g. known bad domain names, IP addresses and hashes. Although important, the targeted attacks with same IOCs may not be a best

[27] https://www.betaalvereniging.nl/en/safety/tahiti/

use of the threat hunt team. Therefore, as team gains maturity, should focus on (or prioritize) top three layers of the pyramid as it can yield high value.

2. Other factors: Apart from general prioritization addressed above as per TaHiTI, following factors should be used for prioritization based on its importance.

    1. Regulatory Requirements: these could allow organizations to maintain their license to operate. Therefore, organizations must prioritize these if requirements change or new requirements for detection and reporting are imposed.

    2. Historical Security Incidents: Historical incidents provide important data points for hunts because those are successful violations of security controls and policies.

    3. Vulnerabilities reported after red team exercises / penetration testing: like historical security incidents, the pen tests or red team exercises provide the TTPs that have been successful.

    4. Risk evaluations of threat hunt ideas: Each threat hunt idea should be evaluated for the risks to the business. If risk to the operational continuity, safety of employees or community, financial or reputational status of the organization is sever, team must prioritize

    5. New Threat Intelligence data: Threats may go dormant or may choose to hibernate for a period. New Threats may emerge or dormant threats may suddenly become active again. The prioritization of threat hunts may get influenced due to this.

        1. A potential threat is more likely to have more impact if it involves observations supporting many different hunting hypotheses. These threats and TTPs should be prioritized above other hunts.

2. The absence or downward trend of threat activities does not guarantee that organization won't find it in their environment. Organizations may tend to deprioritize those hunt ideas. Reprioritization of those hunts could be considered. However, those should not be removed from backlog.

Scheduling

Within any organization scheduling is a major pain point, simply because amount of time needed to build the schedule, manage employee availability and other organizational constraints. In the threat hunt organization, team would need two different types of scheduling focus as detailed below. In any case, team should remember, scheduling is not a one-time activity. It is continuous and on-going effort. Regular status reporting, updating of the schedule and the management of schedule changes on a regular basis ensures the schedule is "useful".

Resources Scheduling:

Resource scheduling is very important for the Threat Hunting group to schedule threat hunts by using organizational resources in most effective and efficient manner. Resources are the are primary sources of productivity and profitability upon which organizational strategies are frames. Organization has finite resources; therefore, resource scheduling methods must incorporate time and resource capacity into the scheduling process. There are predominantly two methods of resource scheduling[28]:

1. Time-constrained scheduling: assumes that time constraints are fixed and activities must be undertaken within defined time constraints. This method assumes

[28] https://www.pmi.org/learning/library/resource-scheduling-capacity-schedule-construction-5376

1. Resource-constrained scheduling: assumes that the resources are finite. Therefore, it emphasizes that task activities must be conducted primarily within resource constraints.

Team should remember, no one technique is perfect. The managers should combine these techniques to effectively plan and schedule the hunts.

Here are few scheduling techniques that will help speed up your threat hunt scheduling process:

1. Maintain Threat Hunt Backlog: Within agile project management, product backlog term is referred often. It refers to a prioritized list of functionality which a product should contain. It is sometimes referred to as a to-do list, and is considered an 'artifact' within Agile Scrum framework. Threat hunt team should use this concept to maintain the list hunt requirements and ideas collected by the team. Establishing an appropriate backlog is very important. When teams have too little work in the backlog, there is a risk of sitting idle. That wastes time and money. On the other hand, when teams have extensive backlogs with excessive detail, the business runs the risk of having over-invested in the plans that can change. That also wastes time and money. Therefore, a middle ground is essential. The entire backbone of planning depends on the goals and resources required for the hunt. Therefore, team should maintain these requirements in the backlog.

2. Ensure staff and resources availability: Team should manage general availability by having employees mark what times and days they are not available. General availability consists of days or times when a person is normally unable to work. The availability management should be extended to other required resources as well. It is possible that organization has finite hardware and software resources needed for the.

3. Use a template: Find a template that you are comfortable using that helps you get your job done faster. A lot of companies use Excel for this, which can be kind of difficult to manage, but pick something that works well for you.

4. Create a schedule based on the employee's skills and resources available: It is important to create a schedule that matches the right team member to the job at hand. E.g. Hunts that focus on collecting and analyzing network telemetry should be managed by networking subject matter experts. Hardware and software resources required for hunts may constrain your ability to freely schedule hunts. Therefore, scheduling process should include employees and other resources needed for hunts.

5. Evaluate the scheduling process: monitor and evaluate your schedule in real time. Use visual way to spot the gaps, overlaps, and potential errors in your scheduling process.

6. Effectively communicate: All organizations know the importance of communication, and no more important is effective communication than where employee schedules are concerned.

Threat Hunt Project:

Above, we discussed scheduling constraints and best practices for the operational threat hunt organization. Now let us look into project management, i.e. managing threat hunt. Each threat hunt is a time bound activity with specific inputs and expected results. Therefore, threat hunts are like projects. Breaking down hunt in manageable tasks is essential. It allows the team to schedule (determine the timeline), and reality of the delivery of the hunt. Scheduling is an integral part of project management; therefore, it has been a key knowledge area in Project Management Institute[29]'s (PMI) core publication - Project Management Body of Knowledge (PMBOK® Guide). Here is a simple guidance for threat hunt project scheduling:

1. Develop a reusable Work Breakdown Structure and Work Packages: A reusable work breakdown structure should be maintained. This can be

[29] https://www.pmi.org/

optimized for specific hunts as needed. The work breakdown allows the team to refine work packages (tasks) needed during the hunt.

1. Schedule: Work packages can be used to assign duration, identify task interdependencies and resources needed to complete specific task.

Use a template for Project Plan: Project planning templates or software tools allow you to create and maintain the detailed project timeline effectively. Microsoft Project tool is widely used. However, Microsoft Excel can be used as well. PMI has several ready to use templates [30]that can be used for this.

Automation

Pioneered by Google through their "Hunt Once" approach which asks hunt teams to design and execute a threat hunt one time and then build an automated hunt that can run continuously as a detection. Automation is a fantastic way to scale threat hunting operations so a small team of hunters can execute effective hunts against large environments. Additionally, automation enables hunters to dedicate valuable time to developing new and interesting hunts using complex datasets and analysis techniques rather than executing the same hunts on a regular interval.

Not every organization will have the people, processes, or technology to implement automation however, given the benefits of automation all threat hunting organizations should consider building a roadmap leading towards automation.

Core requirements to transition threat hunts to automated detections

- Accurate, Complete, Consistent, Timely, Unique, and Valid datasets within high availability tools that can maintain a continuous search and trigger a notification when the hunt conditions are met.

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[30] Project Management Templates

- Well-defined and validated hunt that is highly tuned on hunt signal that will not decay
- Defined criteria to identify and approve hunts for automation
- A defined process to migrate a hunt from the threat hunt team to the security operations team or the technical capabilities to create custom software or tools through a defined automation standard such as Robotic Process Automation
- A documentation standard for all automated detections

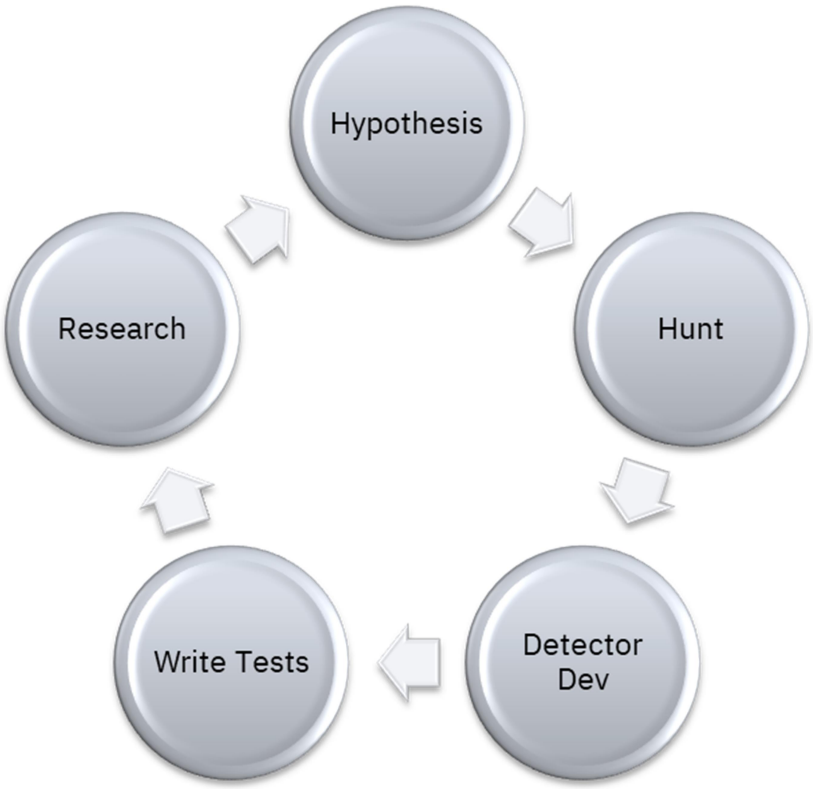

Figure 16: Google Hunt Once Process

Identification

The first step in building an automation identification process is to understand the strengths of humans vs computers.

Humans are exceptional at dealing with:

- Uncertainty
- Ambiguity
- Pattern recognition
- Decision making
- Judgement calls when circumstances change

Computers shine when:

- Consistent execution of the same process is required
- When a process or activity is required to scale rapidly
- When a process requires fast computational processing or complex condition matching

The hunts that are most likely going to contain characteristics that are more suited for automation are:

- Time-consuming and time critical hunts with high transaction volumes. These hunts hinder human performance but not computers.
- Repetitive hunts that require constant execution will have a bigger positive impact than the ones that are executed occasionally.
- Hunts that are prone to human error due to their computational and conditional complexity
- Hunts that require data fusion or from disintegrated systems can result in human error, so such processes are well suited for computers.

Automation through Security Operations

Hunter hunt, they should not triage alerts. Clear roles and responsibilities should be created between threat hunt and SOC teams when considering threat hunt

automation. The expectation of the threat hunt team is that any hunt that is going to be automated should be so well designed and documented, that the SOC team should not need to deal with any of common issues with weak detections such as false positives and constant tuning. Conversely, the SOC should be expected to take responsibility for transitioning the hunt to an automated detection and apply internal documentation and testing standards.

One of the best frameworks for creating and managing automated detections is Palantir's ADS Framework[31]. The ADS is a well-designed detection documentation and management framework which implements detection documentation in the following manner. This natural language template ensures that any given alert will have sufficient documentation, will be validated for durability, and reviewed prior to production deployment.

- Goal
- Categorization – MITRE framework mapping
- Detection Strategy
  - Data Sources – what data sources to consider/needed for searches
  - Suppression – what is known good state to filter (processes and network based)
  - Action
- Technical context: details of TTPs, related data sources and how it is an evidence of adversary presence
- Blind spots and assumptions:
  - Blind spots occur when assumptions are violated.

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[31] https://blog.palantir.com/alerting-and-detection-strategy-framework-52dc33722df2

- False positives: what false positives are feasible based on known good and search criteria
- Response: how organization should response if threat hunt provides a positive result, i.e. detects the presence of adversary in the environment.
- Other relevant resources

For more information regarding the ADS, reference the ADS GitHub project[32] here:

- https://github.com/palantir/alerting-detection-strategy-framework
- https://blog.palantir.com/alerting-and-detection-strategy-framework-52dc33722df2

Robotic Process Automation (RPA)

For organizations that have the technical capabilities to design custom solutions for automated threat hunting, the Robotic Process Automation[33][34] (RPA) can be used as a framework to ensure that any automations are well-designed, effective, and well documented. RPA is a form of business process automation that allows organizations to define sets of instructions for a "bot" to perform. RPA bots are any technical mechanism that replicate human-computer operations to carry out a ton of error-free tasks, at high volume and speed. RPA software utilizes RPA bots to automate routine tasks within software applications normally performed by a human. These bots are designed to eliminate the need for humans to conduct time-consuming, repetitive, and tedious tasks. Threat hunting operations can leverage RPA software to develop custom bots to execute threat hunts that have been identified as good candidates for automation. There are many RPA software

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[32] https://github.com/palantir/alerting-detection-strategy-framework

[33] https://en.wikipedia.org/wiki/Robotic_process_automation

[34] https://www.techtarget.com/searchcio/definition/RPA

vendors available. Organizations will need to find the right vendor or product to suit their budget and operational needs.

Continuous Improvement

Continuous improvement is any strategy, framework, or process that organizations implement to provide sustained and structured efforts towards improving business functions. Threat hunt teams that implement a continuous improvement strategy and actively seek improvement opportunities will have a much better chance at generating value over time for both the organization and for hunters. Value comes in the form of improved analysis capabilities, data quality, metrics, and reduced risk due to threats.

Kaizen, a continuous and never-ending quest for improvements is essential for Threat Hunting program. Threat Hunt program cannot exist in vacuum. First and foremost, hunting is an essential component of security program continuous improvement. This section, however, aims to focus on improving the efficiency, effectiveness, and quality of each component of hunting process.

Continual Improvement Model

The lessons learned activity must be carried out after each hunt. Lessons learned feedback and documentation should ensure that the team retrospectively reviews and analyzes all process areas of threat hunting. The analysis should provide the details: if objectives of threat hunt were met such as quality of threat intelligence data, workflow applicability, organizational environment, the data reliability gaps, if the team was adequately staffed with skilled resources, and if the time allocated was adequate.

The purpose of continual improvement is to ensure the service, offering, or product remains aligned to the organization's goals. As it applies to threat hunting, this requires visibility into the operation in entirety, as the overall improvement of the operations is the result of improvement realized at all levels. This includes

people, processes, and technology all are expected to perform at the requisite level to facilitate value.[35]

One of the more important aspects of a successful threat hunting operation is the ability to effectively demonstrate the value threat hunting brings to the organization. The Continual Improvement Model (CIM) is a highly effective way for threat hunt teams to implement a culture of improvement and establish a pipeline of data points that can be expressed to senior management to show how threat hunting is improving and bringing value to the organization.

QPR International describes implementation recommendations for the ITIL Continuous Improvement Model through the following steps[36]:

What is the vision?

- The improvement should always support the organization's goals and objectives.
- It should also link individual actions to the future vision, in order that it really can be seen as an improvement.

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[35] https://www.knowledgehut.com/tutorials/itil4-tutorial/itil-continual-improvement-model

[36] https://www.qrpinternational.be/blog/it-governance-and-service-management/itil-4-continual-improvement/#:~:text=The%20ITIL%204%20continual%20improvement,Service%20Value%20System%20(SVS).

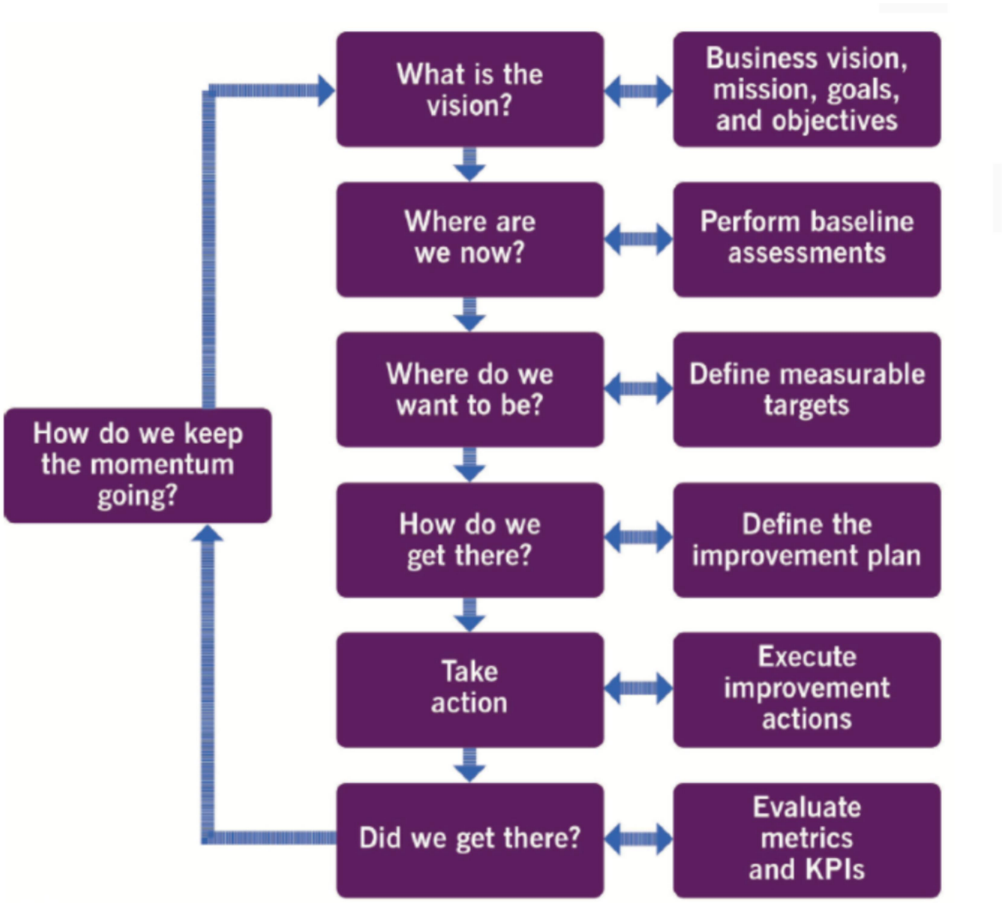


Figure 19: ITIL Continuous Improvement Model

Where are we now?

- For an improvement to really impact, it should have a clear starting point. The step 'where are we now' helps you to assess your current situation, from a technical, human resource and user's perception perspective.

Where do we want to be?

- This step helps you visualize your improvement initiative.
- Here you set your Key Performance Indicators (KPI's) and the objectives of the improvement initiative.

How do we get there?

- The fourth step helps you plan. The continual improvement model advises to work iteratively, however with some initiatives this might not be needed, and another approach will suffice.

Take action!

- Execute the plan that you created in the fourth step. A measurement process is key in this step as it will help you stay on track. To execute the plan, you can use any type of approach that you think fits best (waterfall, big bang or small iterations).

Did we get there?

- Check and confirm the progress and the value of the improvement initiative.
- If the desired result has not been achieved, additional actions need to be taken (often in a new iteration).

How do we keep the momentum going?

- If the initiative is a success, use it to build support and momentum for the next improvement initiatives.
- To do so, share the success both internally and externally. If the initiative failed to achieve success, make sure to use it for your 'lessons learned'. This way the initiative did create value, even though it was not a success.

Maturity

The Open Group information security management maturity model (O-ISM3) describes a maturity as the measurement of an organization's ability implement continuous improvement practices within a particular discipline. With a focus on continuous improvement, maturity models are well suited for assessing threat hunting operations.

Why maturity models are important for threat hunt teams:

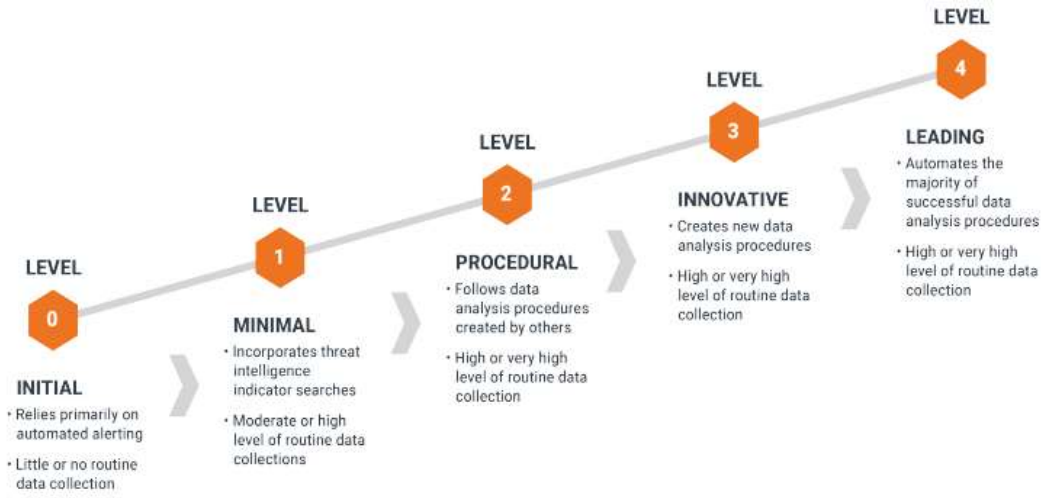
- Benchmarking – Determine where the threat hunt team is in terms of current state and compare against goals and objectives for performance improvement.
- Performance Improvement – With a model a threat hunt team can directly track their operations against the best practices defined by the model. Maturity models can help organizations identify gaps which a plan that addresses specific issues.
- Unified improvement language – Implementing a maturity model ensures that the entire threat hunting organization is aligned on future goals and using the same language to discuss capabilities that would enable the organization to increase their maturity with respect to the model.

The SQRRL "A Framework for Cyber Threat Hunting"[37] white paper is one of the most important papers released to the world of threat hunting and serves as a foundational part of the OTHF. Within SQRRL's works, they introduce the concept of threat hunting specific maturity model and a set of criteria in which a threat hunting program can be evaluated against.

Through the introduction of a maturity model, SQRRL created a way for threat hunt teams to build short-, medium-, and long-term goals through some high-level characteristics associated with the varying levels of maturity. Depending on the organization, they may want to have more specific requirements and assessment criteria laid out within the model and so the OTHF has created a maturity model that organizations can use to assess their maturity against.

SQRRL Maturity Model

[37] https://www.threathunting.net/files/framework-for-threat-hunting-whitepaper.pdf



SQRRL Hunting Maturity Model

Full details of the SQRRL Maturity Model can be found in the whitepaper: https://www.threathunting.net/files/framework-for-threat-hunting-whitepaper.pdf

OTHF Maturity Model

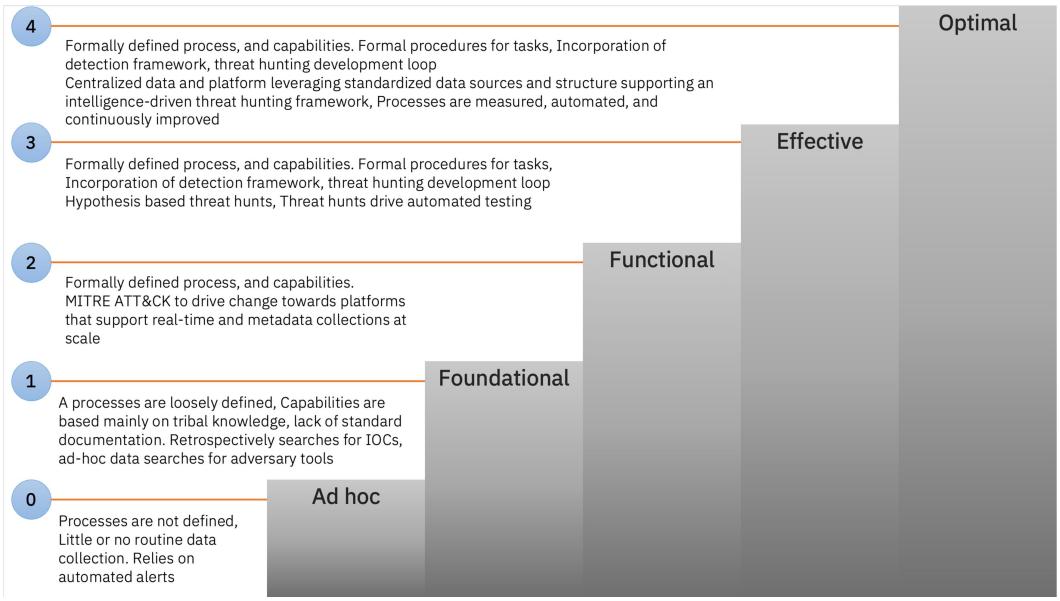


Figure 2: OTHF Maturity Model

Assessment Criteria

This section outlines the assessment criteria for each process area in scope

	LEVEL 0	**LEVEL 1**	**LEVEL 2**	**LEVEL 3**	**LEVEL4**
PEOPLE	- A threat hunting role does not exist or is informal - A skills catalog does not exist. No hunter training program is available	A threat hunting team exists but role description and expectations are informal documented and communicated. - A rudimentary skills catalog exists, with no defined criteria, requirements, or a plan. No hunter training program is available.	A threat hunting team exists with dedicated roles and expectations are formally documented and communicated. - A functional skills catalog exists, with defined criteria, requirements, or a plan. However, the skillset is assessed by the TH program leadership on an ad hoc basis. There is no formalized plan for addressing gaps. No hunter training program a	- A effective skills catalog exists, with defined criteria, requirements, or a plan. However, skillset is assessed by the TH program leadership on a ad hoc basis. Criteria and requirements are defined, and a formalized mentoring program is in place for bridging the skills gaps - A formalized training program is established for all levels of hunters. - A formal recruiting plan is in	- A robust skills catalogue exists, with a defined criteria, requirements, or a plan. However skillset is assessed by the TH program leadership as well as through self-assessment on a regular basis. Criteria and requirements are well defined, and a formalized mentoring program is in place for bridging the skills gaps. -A cross training program is in place for inter-departmental

				place.	training - A formal recruiting plan is in place.
PROCESS	- A hunting framework does not exist or is in its infancy - Threat hunting does not exist	- A hunting framework is informally documented - Threat hunting is mainly a reactive service when incident response activity arises - The process area covers less than 50% of the organization	- A hunting framework is formalized and documented - Threat hunting is proactively continued regardless of incident response activities - No automated detection framework in place. - The process area covers 50% to 75% of the organization	- A formalized hunting framework is regularly executed. Outcomes are consistently discussed with impacted stakeholders. - A Threat Hunting mission statement has not been defined. - Hunts are constantly documented and reviewed with the ability to be turned into automated detection - The process area covers 75% to 90% of the organization	- The threat hunting frameworks is regularly reviewed and validated for efficiency. - A clear Threat Hunting mission statement has been defined and understood by the team. - Stakeholder feedback validates that the hunt outcome meets or exceeds expectations. - Newly developed are shared with the threat hunting community. - Hunts are constantly documented and reviewed and turned

					into automated detection - The process area covers 90% to 100% of the organization
DATA SOURCE	- Visibility on data sources is unknown - Quality of data sources is unknown - No tools or processes to passively collect data	- Visibility on data sources is partially understood - Data sources are informally documented - Tools are present to passively collect data - The data sources covers less than 50% of the organization	- Visibility and quality of data sources are informally measured - Available hunting data sources are formally documented - Collection tools are part of the threat hunt program too actively collect data - The data sources covers 50% to 75% of the organization	- Visibility and quality on data sources is formally measured and in place - Data collection is executed consistently - Hunting techniques include data science - The data sources covers 75% to 90% of the organization including critical assets	- A standard exists for enterprise wide logging and documentation - Standardization of hunting data sources is fully automated - Hunt operations include data science techniques - The data sources cover 90% to 100% of the organization across network and endpoint.
THREAT INTEL	- Threat intelligence is not a function within the	- Threat intelligence sharing is reported on an ad hoc	- Threat intelligence sharing is a separate function	- Threat intelligence sharing is a separate function	- Threat Intelligence is a key function that allows the business

	organization or is still in its infancy - Threat intelligence is never or rarely collected - No CTI technology - No technology integration or Data is raw and unformatted.	basis. Expectations are informal documented and communicated. - Threat intelligence scope is global and org specific - Threat Intelligence platform exists with updated feeds - Technology Integration: SIEM, Firewall/Proxy, or IDS/IPS	within the organization and expectations are formally documented and communicated. -Threat intelligence scope is global, org specific, and industry specific. - Teams take external and internal data input to shift from a reactive to a proactive posture. - Threat intelligence platform exists alongside an IOC tool - Technology Integration: TIP, SIEM, Firewall/Proxy, or IDS/IPS is being integrated within threat intel	within the organization and expectations are formally documented and communicated. - Region-specific, global, industry-specific, org specific - Contributors and members of organizations such as Information Sharing and Analysis Centers (ISACs) and Information Sharing and Analysis Organizations (ISAOs) - Automation of some threat intelligence analysis tasks - Technology Integration: TIP, SIEM, defensive tools, incident	to make operationally and strategically aligned decisions. - Create tactical an strategic TI - Team has the capability to build custom applications and processes - Majority of TI is automated - Advanced analytics and orchestration capabilities - Region-specific, global, industry-specific, org specific - Contributors and members of organizations such as Information Sharing and Analysis Centers (ISACs) and Information Sharing and Analysis

				response system, and all security data is being integrated within threat intel - Supports IR engagements based on knowledge of the adversaries involved	Organizations (ISAOs) - A sophisticated threat intelligence platform exists that allows the team to build out a SOAPA
METRICS	- Few or no metrics are identified, tracked, or reported	- Key metrics are reported on an ad hoc basis - Key metrics are identified and measurement elements are accurate	- Performance targets such as operational metrics and key performance indicators is accurate and communicated to management	- Metrics are formally tracked and reviewed. Output is communicated and reported to management on a regular schedule. - Improvements are discussed but not a critical priority	- Improvements are prioritized for areas where performance is not meeting target goals. - Operational metrics are updated in real-time via automation - Hunt outcomes included in risk assessments

Measurement

There's a famous quote by Stuart H. Britt that says, "Doing business without advertising is like winking at a girl in the dark, you know what you're doing, but nobody else does." And while this quote is specifically about business and

advertising the same thing can be said about threat hunting and documentation. You can be one of the best hunters in the world, or have one of the best teams of hunters in the world, but if you're not documenting what you're doing, no one's going to *know* what you're doing.

Threat hunting is called 'hunting' for a reason. It's the process of searching for something that's not currently being detected, searching…not necessarily finding. Of course, that doesn't mean there's not value in the time spent hunting that doesn't lead to an attacker. It's important to remember that just because something you find isn't evil doesn't mean it isn't interesting.

Documentation and metrics allow you to demonstrate the value of the time spent hunting, not just to management, though that's a huge part of it, but also to the rest of your team. It allows you to share what you focused on, what you learned, how it was beneficial or not, and how the discoveries you made can be replicated by following the paths you took. It provides opportunities to share processes and techniques with fellow hunters through white papers, conference talks, or even something as simple as a tweet. The things that you're doing have value and if writing them down and sharing them stops one more attacker, or helps an organization reduce their attack surface even by a little, isn't that worth it?

The Selfish Side of Metrics

We're going to give you plenty of reasons you should document your hunts and how they demonstrate value to the organization, but what about value for yourself? All of the metrics we're going to discuss are beneficial to the hunter as well. It's exactly the type of data that looks fantastic on a performance review. When that annual review comes around and you can say "I've worked X number of hypotheses, which led to the identification of Y vulnerabilities and Z number of misconfigurations. I also detected X number of attackers causing the discovery of Y breaches that had gone undiscovered for Z months.", it's not going to hurt. So even if your motivation is purely selfish, that's okay, write it down, all of it.

Defining Success

Before you can decide if your efforts are successful you need to determine what success looks like. Success for one organization won't necessarily translate into success to another. Success and the criteria around that success are personal things. Do you want to discover a certain number of misconfigurations? Are you looking for gaps in your security structure? Are you trying to find users violating company policies? Or are you looking for a certain number of attackers?

These are all great questions to ask yourself and your leadership. Understanding what's expected and focusing on meeting those goals can translate into additional hours allotted to hunting, additional full time threat hunters, or additional tools and resources to make your hunts easier or more focused. All of these are good things.

Measuring Success

Measuring success doesn't have to be done with fancy tools or solutions, you can measure success using any method that works for you, your team, and your organization. Just like defining success, this is something you should discuss as a team and decide what works best for you.

With that in mind, the following are a few things that can make documentation and metrics easier to manage:

- Choose methods of documentation that are easy for your hunters to use. If the process and tools you select are ones the team isn't interested in using you're going to have a much harder time getting quality results from them.
-
- Use a method that's shareable with the entire team. This allows hunters to keep notes on what they're currently engaged in so that if they feel the need to hand off the hunt at the end of a shift the next hunter can pick up right where they left off without an extensive handoff.
- Use something that's searchable. You want to design your documentation in a way that allows it to not only act as a record of things done in the past, but

also a knowledge base on what may have triggered a hunt, and what its eventual outcome was. This can be incredibly useful to junior hunters as this will give them the ability to 'look over the shoulder' of other team members and learn from their methods and experience.

Defining Metrics

Now that we've talked about what success looks like and how to measure it we're going to want to decide what metrics are worth collecting. Since you're a threat hunter you'll recognize that a pattern is emerging here. What you collect and what's important is up to you to decide but we'll give you some suggestions to build on.

This list shouldn't be considered complete, or in any way exhaustive. These metrics are meant as a good jumping off point to identify and develop the metrics that matter to you. They should drive conversations between your team and management to decide what has the most value to you. Try to keep in mind that the more data you can collect about your threat hunting practice, the easier it'll be for you to make the case for more time and resources to hunt with.

Hunt Tracking

Each hunt should begin with some type of hypothesis, which is just a question to answer or assumption about the environment. While the best hypotheses are born from threat intelligence or an offensive mindset it won't matter how good they are if they're not written down. As with many aspects of hunting, this doesn't have to be complicated, a simple method of documenting what the hypothesis was, what data sources were used, and what lessons were learned is enough to show the value, or absence of value, while providing a record of where you've been and what investigations generated the most actionable results.

Here are some things you'll want to include when documenting your hunt:

- The Hypothesis Itself – This is the actual question you're asking or theory you're putting to the test. This could be something like "If data was being

exfiltrated from our environment we believe it would most likely leave from X egress point." or "We believe Cobalt Strike C2 beaconing could be taking place on our network."

-

- Threat Intelligence Sources – What threat intelligence was used in order to develop this hypothesis or help with its investigation. This should be documented because as you work through each hypothesis you'll find which threat intelligence is of most value to you and your organization. Is there a certain source or two that keeps As there are an overabundance of threat intelligence sources available, even this data has value.
- Data Sources Used – What data was required to prove this hypothesis? Knowing that you have access to the appropriate data necessary to do the investigation is a huge step in identifying if you have blind spots. Write this down, find those blind spots, and correct them. More visibility means more avenues for detection.
- Operating Systems Investigated – If you're focused on hosts then knowing where that focus lies is key to any future mitigations created or for the development of junior hunters who might need additional experience with certain OS's. Remember, this is also a knowledge base.
- Network Protocols Investigated – When hunting within network data you'll want to make sure each protocol you used in the investigation is documented as well. A quick glance at this field will allow senior hunters to identify if something could have clearly been missed but also will clue them in to any analyst biases that may appear based on the focus of the investigation.
- Indicators and Enablers of Compromise Discovered – While hunting doesn't always lead to evidence of a breach, sometimes it does. This is high value information and key to documenting the investigation. It's also critical to creating future mitigations. This also holds true for enablers of compromise. While not evidence of a possible breach an EoC might give an attacker an

advantage while attempting to gain entry to, or persist within, an organization. This could be using cleartext protocols, improper network segmentation, unpatched servers, etc. EoCs broaden our attack surface, their discovery, documentation, and resolution are critical to any security program.

- Mitigations Created – After discovering any IoCs, EoCs, or data of interest we're going to want to take action. While the hunter themselves may not always be responsible for this step, they're going to need a clear path to escalate any findings. This could be creating a new alert, writing a new report, creating a new automation playbook, aging out some old threat intelligence, or any number of other tasks. The point is, hunting should provide results, and this field should be full of them.

- Hunters Involved – Knowing who participated in a hunt allows you to see where each of your hunters is spending their time, the results they're delivering, and who to go to when you need someone to speak to the data. There are lessons to be learned and stories to tell from every hunt and these are your storytellers.

Programmatic Metrics

When you're looking at your program and attempting to communicate what it provides back to the organization, these metrics are key. They may seem simple, or maybe just not as technical as our attack surface metrics, but they're what management wants to hear when you're discussing how threat hunting is being used to improve your SOC or CIRT.

- Number of Hunts Conducted – Incredibly straightforward. How many hunts are you doing? Correlating this metric with the time spent hunting and their results can lead to insights about which hunts are the most valuable to your organization.

- Hours Dedicated to Hunting – Speaking of time. Understanding the amount of time spent overall, as well as on individual hunts, will help you align

expectations on particular types of hunts and the time required to perform them effectively.

- Alerts Created – There are many cases where a hunter will discover something that can be turned into an alert. Tracking how many alerts are suggested by your hunters will allow you to understand the number of alerts created in house versus from external sources and what the difference in the value of those alerts might be.
- Reports Created – A hunter may discover some data of interest that's not alertable, but is worth looking into. Daily or weekly reports can be a great source to initiate a hunt or task an analyst with investigating. For example, having an analyst look at a report of the least common processes running on a small number of endpoints in a large organization. This could be completely normal for the environment, but it's worth looking at the outliers and the data is always changing. You don't need an alert, you need a report.
- Threat Intelligence Generated – Hunters can provide you with intelligence that is directly tied to your organization by looking at an undetected attack and "We saw this type of activity, from this region, in this area of network.' Hunters are also a great source to identify threat intelligence that should be decommissioned from your program as hunting using old threat intelligence can be incredibly frustrating and can misuse the limited time dedicated to threat hunting.
- Automation Playbooks Created – While you can't automate threat hunting completely, there are types of data collection or responses to certain type of data that can be automated. The goal is to focus our hunts and investigations on the most actionable data we can. Document why a new playbook is recommended and how it can help the SOC and your hunters, the expected time saved by implementing this playbook is a great metric to capture as well.
- Declared Incidents or IR Engagements Generated – Documenting how often a hunt leads to evidence of an actual breach is crucial. Most organization, and

even many security professionals believe that this is the sole benefit, or goal, of threat hunting. Comparing the number of declared incidents triggered by threat hunting versus traditional alerts can also demonstrate the value of hunting in identifying the most critical attacks.

- Data Source Blind Spots Discovered – When attempting to prove out a hypothesis hunters may discover that the organization is lacking access to the data necessary to identify evidence of a particular attack technique. Identifying these gaps in visibility and correcting them before an attacker uses one to go undetected is incredibly valuable and should be documented and shared.

- Security Recommendations Communicated – At times hunters may identify a misconfiguration, gap, vulnerability, or technology that's not working as it should or is leaving the organization exposed to potential attacks. A mechanism to receive feedback from hunters on what could be done to improve the security of the organization should be part of any hunt program.

- Community Engagement Opportunities – Threat hunting provides an incredible number of learning opportunities both for the hunter themselves, the team they belong to, and the organization as a whole. But what about sharing what they've learned or how they've learned it? If your hunters are writing white papers, giving conference talks, or sharing their methods in some other way, you'll want to make sure you're keeping track of these things. Community engagement can lead to ideas, innovations, and information sharing that will not only increase the overall security of your organization but increase its brand recognition as well.

Attack Surface Reduction

At the end of the day this is what it's all about. We're trying to reduce risk to the organization and reduce our overall attack surfaces, it's why security exists, it's our ultimate goal, and threat hunting helps us get there. There are a lot of ways to show value

Here are some of the metrics you can focus on when deciding what to track and what to set aside. This list is long, you don't have to try to do all of them, but a selection of the following will give you a good place to start and allow you to shape and focus your metrics collections based on the feedback you receive from your team and from management.

- Advanced Persistent Threat Group TTPs Investigated – Knowing what business you're in and who the most likely attackers to target that type of business are will allow you to focus your hunts on the TTPs that those groups use. Being able to go to management and say "We've identified these 5 groups as our most likely attackers and we've spent X number of hours conducting Y number of hunts to ensure we don't see evidence of the attack techniques those groups use in our environment." is going to have a huge impact on the perceived value of your threat hunting efforts. Give your CISO what they need to make the case for more resources for you and your team. This metric does that.
-
- MITRE ATT&CK IDs Investigated – ATT&CK is an invaluable source of the kind of threat intelligence that really matters, TTPs. Decide which techniques are relevant to the technologies you have within your organization and look for evidence of those TTPs. Move through them systematically from most likely to least likely and document your journey.
-
- Misconfigurations Discovered – Some vulnerabilities aren't malicious or aren't failings in the design or coding of an asset. Sometimes they're just not configured correctly. Admins might believe that they've done everything right, that they've secured the system as requested but sometimes looking at the traffic being sent, or the behavior of the device itself shows that despite the best intentions mistakes can happen.
-

- Vulnerabilities Discovered/Identified – Finding evidence that a vulnerability exists within your environment before an attacker does is critical to attack surface reduction. If your hunters are seeing vulnerabilities in production this can identify a gap in your vulnerability assessment program, closing these gaps allows you to shore up your defenses and increase your coverage before an attacker has the chance to use this against you.
-
- Cleartext Protocols in Use – Cleartext protocols exist in every environment, even ones that don't think they're using them. Are you aware of how much FTP traffic leaves your organization? Why are you still using clear text protocols when encrypted alternatives exist?
-
- Overall Percentage of Encrypted vs Unencrypted Traffic – This is a simple metric but one that any organization should be aware of. What the *actual* amount of encrypted traffic that's traversing the network is and whether that's leaving your defenders blind are questions you'll want to answer. Knowing what your threshold is and at what point you may need to implement a decryption solution will allow you to forecast that expense and communicate your need to management as that time approaches.
-
- Cleartext Usernames/Passwords Discovered – An incredibly common part of any breach is credential abuse, whether being used for initial entry or for lateral movement and persistence, cleartext credentials can cost you dearly. Document the number of times you see credentials left in the clear in config files, general documents, or passed on the wire. Even if those credentials are only being seen internally, just one level of compromise can potentially give the attacker the keys to so much more.

- Insecure Systems Identified – You may be searching through web traffic and discover that the browser that's sending data is incredibly old, or a web server is unpatched, or that the operating system is currently vulnerable to an attack with a readily available patch. Sometimes systems are missed or misplaced, finding and closing these gaps before an attacker does is critical, but you can't trust that everything has been taken care of, you have to go and look.
-
- Unaccounted for Assets Discovered – At times you may discover an endpoint, or many endpoints, that you don't have a record of. We've seen this range from a single server to an entire building's worth of assets. Without proper asset management we're blind to what we're defending. Keep a record of what was discovered and why it went unaccounted for so you can close the gap on the asset itself as well as potentially improve the process for discovery.
-
- Attacker Tools Discovered – Evidence that any type of attacker tool in the environment is something you should be keeping careful track of. If it might be seen in a Kali distro and it's now in your environment, why is it there? Who put it there? When did it arrive? Even seeing an attacker tool being deleted from your antivirus logs could be worth investigating. AV did its job, but why was that being written to disk somewhere in the first place?
-
- Malware Discovered – Speaking of malware. Proper investigation of why malware is present on endpoints in your organization can help you understand whether the attack is of a 'spray and pray' nature, or if your user was being targeted specifically. Understanding the difference can have a huge impact on how you respond.
-

- Prohibited Protocols in Use – It's incredibly common to hear thing like "We don't allow bittorrent." or "There is no Tor traffic on our network." Only to discover that's not the case just by looking at the sessions passing through the network. Discovering protocols you've prohibited can mean something as small as a policy violation to a full scale breach. Always inventory your protocols and any deviations from your allowed list.

Communication

An important aspect of any successful threat hunting team is the ability to communicate freely and effectively. Hunt teams should be able to engage different parts of the organization without barriers and as equals

Communication Strategy

No one is going to care how good your team is if you can't communicate how good your team is.

One of the more underrated aspects of designing and operating a threat hunting organization is developing a strategy to communicate with leadership how the investment into threat hunting is generating a positive impact on the organization. If the only message the threat hunt team delivers to key stakeholders and leadership is whether threat hunting identified malicious activity, it will be extremely difficult to realize the full value threat hunting is bringing to the organization.

Detecting malicious activity is clearly part of threat hunting and when malicious activity is discovered through threat hunting, it should immediately be presented to leadership however, threat hunting can also improve the general security posture of the organization by reducing attack surface, improving detection capabilities, improve security data quality, and identify enablers of an attack.

The first step is to identify and generate valuable metrics and KPIs (see the Metrics section of the OTHF for more details on metric generation) which underpin the

communication strategy of the threat hunting program. Without good data to back up your communications strategy there is very little chance for success. At the same time, if all you have is good data the likelihood of that data making an impact on the perception of the threat hunting program to leadership will be reduced.

A communication strategy can help the threat hunt program by tying together the relevant metrics into unified story which stakeholders can not only easily understand the data but also understand why they should care.

A threat hunting communication strategy should include:

- Goal
- Key Messaging
- Target stakeholders
- Metric alignment

Goal – Desired results for the program delivering the communication. The goal should align with short-, medium-, or long-term goals of the program.

Key Messaging – Whenever you communicate, you want each receiver to understand the basic points and takeaways. The basic points and takeaways are the key messages, and each receiver should be able to sum up the point of what is being said within a sentence or two.

Target Stakeholders – A stakeholder is any individual or that has an interest in an organization and the outcomes of its actions. With regards to threat hunting, there will likely be a core set of stakeholders such as the CSO and CISO however depending on the content of the communications, there may be additional stakeholders that will need to be receive the communications as well. Identifying and including the appropriate stake holders for the information is a vital component to effective communication.

Metric alignment – Metrics should not be the main component of the communications, but they should underpin the story of the communications.

Mapping the correct metrics, to key messaging, to the appropriate stakeholders enables the communicator to select the 1 or 2 metrics that quantify the value of a specific data point for the organization, specific business unit, or team.

Goal	Key Messaging	Stakeholders	Aligned Metrics
Highlight how the threat hunt team is becoming more efficient by identify threat hunts which can be automated and how automated detections from the threat hunt team provide the SOC with high quality alerts. Further buy into threat hunting team creating automated detections can be used for increase funding for data sources.	Threat hunting helps the SOC by creating actionable detections Threat hunt team is continuing to scale by automating threat hunts through detections	CSO, CISO, SOC Manager	Number of threat hunts migrated to automated detections past 30 days False positive reductions past 30 days
Goal 2	Key Messaging 2	Stakeholders 2	Metrics 2
Goal 3	Key Messaging 3	Stakeholders 3	Metrics 3

With the communication strategy built, communications become easier to do and more importantly more effective. It is worth the time, to build out a Goal, Key Messaging, Stakeholders, and Metrics mapping for each of the metrics that you are tracking within your threat hunting program.

Communication Audiences

Interdepartmental

Threat hunters should seek out a relationship with all technical aspects of the organization. For example, having a positive relationship with the IT department can lead to a better understanding of why particular applications are included on

the golden image of hosts within the environment, or why a particular protocol was chosen as the method of transit for information throughout the organization. This insight allows threat hunters to understand the inner workings of the devices, applications, and data they're tasked with investigating on a level that will give them an advantage over any would be attackers.

The first thing an attacker will do upon breaching any level of defenses in an organization is to start learning as much about what they've gained access to as possible. They'll try to understand where they are and what's connected to them so that they can maintain persistence for as long as possible. If the attackers are taking the time to learn as much as they can about our environments, shouldn't we?

SOC/CIRT

A critical component of threat hunting is threat intelligence. Threat hunters require the latest, high quality, threat intelligence to know where to spend their time hunting. The type of intelligence that goes beyond indicators of compromise (IOCs) and embraces tactics, techniques, and procedures (TTPs). Working with your team to determine which threat actor groups are the most likely to target your type of organization and what attacks and tools are most likely to come your way can help you focus your hypothesis on areas that will have the most impact to driving down risk to the organization. Hunters should also be feeding intelligence back into the team as it's discovered. Threat hunters can be an incredible resource for intelligence that is highly relevant to the organization because it was found within the organization.

When a hunter inevitably finds evidence of an attempted, or successful breach they will have to be familiar with the incident responders, and the most current incident response plan so threat they can seamlessly shift gears from hunting, to responding.

Threat Hunting Team

An absolute necessity of any threat hunting team is the ability to communicate with one another effectively. To share what hypotheses they're working on, how far down the rabbit hole they've gone, what they've collected, and how they could hand it off if necessary to do so.

Hunt teams should utilize a shared documentation system, something that allows them to see real time notes and data on not only hunts that are ongoing, but all hunts that have taken place in the past. This allows the team to build a threat hunting knowledgebase; a reference when they detect an anomaly to see if it's been detected before and how a previous hunter handled that situation. Data silos and tribal knowledge are not useful for the knowledge of the team, or for the ensuring that the organizational resources that were spent to facilitate the hunts were used most effectively.

While teams will consist of hunters with varying skillsets and levels of experience it's important that any hunter, whether brand new to threat hunting or a seasoned expert, has the ability to review hunt data and call attention to anything they see as a potential concern. All anomalies are interesting and require investigation, regardless of who detected them or whether they ultimately lead to an attacker. Many years ago the airline industry made it an industry practice that any individual involved with an aircraft could raise a concern and all parties must investigate, I repeat, must investigate. From the co-pilot, to the ground crew, to the flight attendant. All parties on or around an aircraft are equal. It's one of the reasons that the airline industry has such an impeccable safety record. Safety comes first, not rank, expertise, or perceived hierarchy. This same mentality should be used within any threat hunting team when it comes to organizational security. If any member of the team has a concern it's taken seriously and a proper investigation is completed and documented.

Leadership

Communicating the effectiveness of a threat hunting team to leadership is a challenge all its own. When the SOC sends a report to leadership they can say "We

received X number of alerts this week which led to Y incidents or escalations." As anyone who has spent time as a SOC analyst can tell you, the alerts just keep coming. Quantifying threat hunting can be much more difficult. Leadership is going to want to know what you're doing with the time spent hunting and how it's leading to a more secure organization. We can do this with our own metrics. We'll get into this in greater detail in the Metrics section of the OTHF but understanding that tracking the number of hypotheses you've created, what was learned from investigating them, and what additional alerts, automations, and reports were created because of them. We'll want to track how many vulnerabilities were discovered, misconfigurations identified, and gaps closed to reduce the organizational attack surface. All of these things are what leadership cares about, and we need to be sure they know what their threat hunters are doing and how their improving the overall organizational posture, and driving down risk.

Appendix

Example Threat Hunting Program Proposal

TBD

Example Threat Assessment

In this example a threat hunter from a mid-sized retail organization will execute a threat assessment using MITRE and ETDA.

Who is targeting?

Using MITRE Navigator and ETDA, the hunter can simply search for the word "retail" as it applies to Groups and Threat Groups. Cross referencing the results, the only adversaries that are listed in both MITRE and ETDA are FIN7 and FIN8. While all of the groups listed as targeting "retail" in either MITRE or EDTA should be assessed, the threat hunter should prioritize the groups that exist within both data sources first.

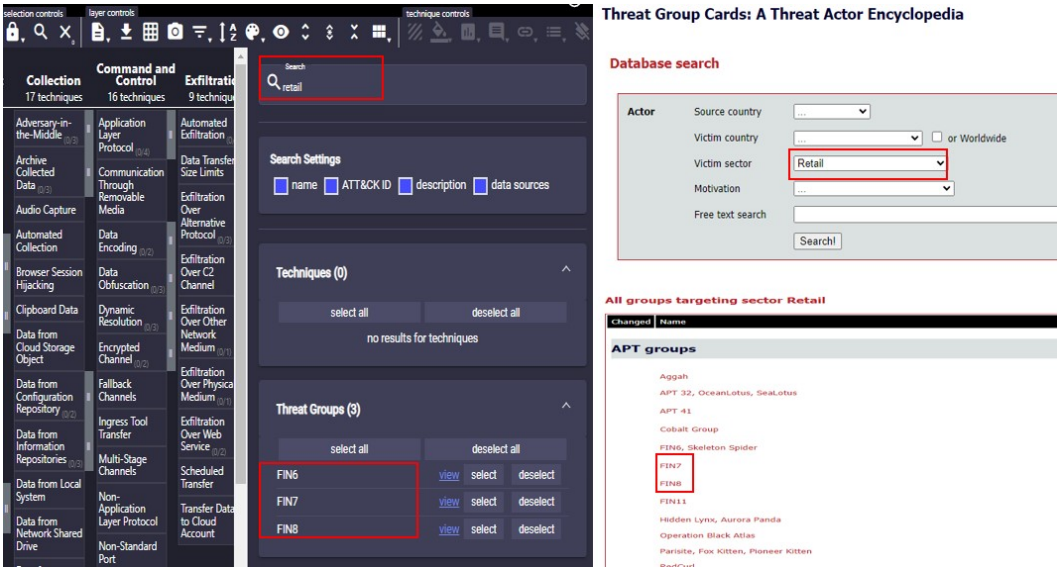


Figure 20: Example Threat Assessment - MITRE Navigator for Retail Sector

What are they after?

MITRE and ETDA have both FIN7 and FIN8 listed as financially motivated adversaries.

How bad would it be?

Based on the data within ETDA and MITRE (at the time of writing), FIN7 attacks have centered around payment card theft and ransomware both of which could result in serious operational, financial, and reputational damages. Assessing the timestamp data (at the time of writing) of the reference materials listed in MITRE and ETDA, FIN7 has shifted their operations towards large scale ransomware attacks.

Based on the data within ETDA and MITRE (at the time of writing), FIN8 attacks have centered around payment card theft through point of sale (POS) malware which could result in serious financial and reputational damages.

Assessing the timestamp data (at the time of writing) of the reference materials listed in MITRE and ETDA, FIN7 has been more active than FIN8 and ransomware has the potential impact to shut down business operations.

Based on the data available to the threat hunter, FIN7 should be prioritized.

How would they do it?

With a particular threat actor in mind, threat hunter can use MITRE Navigator to visualize the techniques associated with FIN7 and can visualize the techniques as they are used throughout the MITRE Tactics.

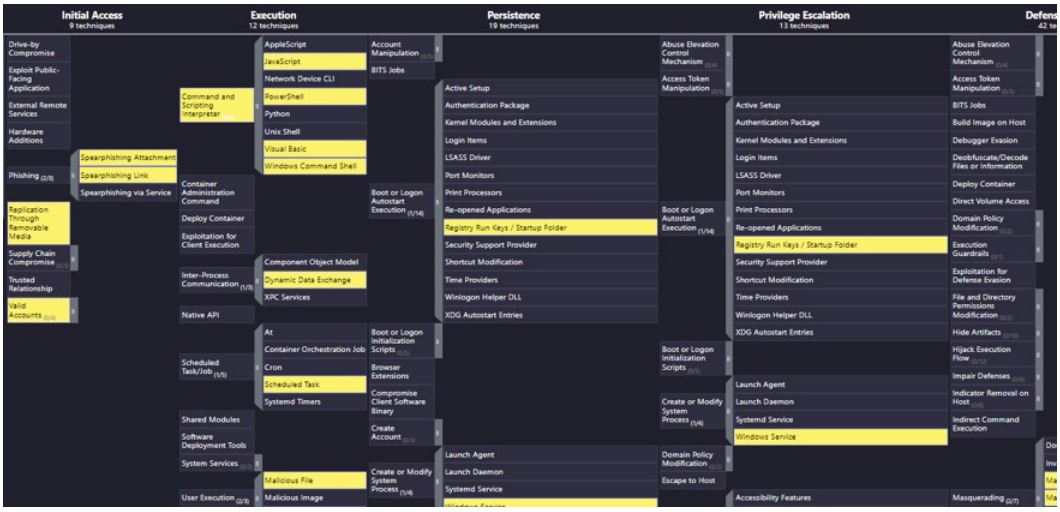


Figure 21: Example Threat Hunt - MITRE Navigator - TTPs

Determining which technique to evaluate first may be determined by the size of the threat hunting program. While there is value in prioritizing techniques which present the most risk to the organization, it can develop into a long-time assessment delaying the hunter from executing a hunt. Prioritizing based on the sequential or reverse order of techniques based on the Tactic flow is a reasonable option, but the threat hunting leaders should decide definitively how hunters prioritize techniques.

In this example, the hunter will prioritize the techniques in sequential order as the are laid out in the MITRE Tactic lifecycle.

Starting with Initial Access, FIN7 is associated with Phishing, Replication Through Removable Media, and Valid Accounts

Likelihood of Success

While having a mapping of a relevant adversary to techniques and tactics is valuable, there may be multiple ways a technique can be used in an attack, or the associated technique may not be applicable to every organization. Hunters can focus their efforts even further by using the resources within MITRE to research specifically how FIN7 uses the associated technique.

The hunter assesses the three techniques and learns that their organization disables the USB port on all of the workstations within the enterprise. While not an undefeatable control, it does reduce the likelihood that FIN7 will gain initial access through removable media. Next, the hunter checks the MITRE technique mapping for FIN7 to determine how they are utilizing Valid Accounts. Based on MITRE, FIN7 leverages Valid Accounts for lateral movement and not initial access. This does not mean that FIN7 does not ever or will never leverage Valid Accounts for initial access, but this allows the hunter to de-prioritize this technique for FIN7 based on the intelligence available.

Figure 22: Example Threat Assessment - assessing likelihood

Within Phishing, FIN7 has associations with Spearphishing Attachment and Spearphishing Link. Based on the hunter's understanding of the organization's security controls, they feel that both techniques are equally likelihood to succeed however based on the reference material within MITRE, FIN7 has been most recently (at the time of writing) attributed to carrying out an attack using Spearphishing Link.

Based on the threat assessment, the hunter has been able to identify which adversary is most likely to be associated with an attack against their organization, what their goals will be, and what techniques they should hunt for first.

Example Threat Hunt Goal

Leveraging SMART to build threat hunting goals is not a requirement but it does provide easy to understand criteria to ensure that hunts are effective, efficient, and easy to operationalize.

Consider the following example in building a SMART goal from a weak goal.

Goal: Detect evidence of ProxyLogon

Assessment: ProxyLogon is the generic name for CVE-2021-26855, the vulnerability that enables attackers to bypass authentication. ProxyLogon is often chained together with CVE-2021-26857, CVE-2021-26858, CVE-2021-27065 which were initially used by the HAFNIUM group to compromise Exchange servers. At its core CVE-2021-26855 enables a remote adversary to bypass the authentication mechanisms within Exchange and perform actions packed within a specially crafted HTTP request with the highest privileges. Given the versatility of the vulnerability adversaries are able to execute requests against various services with Exchange however, threat intelligence shows that adversaries have leveraged the vulnerability to access user mailboxes and upload web shells.

Based on the understanding of ProxyLogon, depending on which component of the exploit or variation of the exploit the hunter is targeting, the required data sources and hunt strategy may vary adding ambiguity to the hunt.

The hunter can strengthen this goal by adding criteria to make it more specific to a specific component of the vulnerability or behaviors resident within different implementations of the exploit.

Specific: Detect successful exploitation of CVE-2021-26855 & CVE-2021-27065 via the Metasploit ProxyLogon RCE resulting in the introduction of a web shell on a Exchange server.

Assessment: While the hunter has added adequate specificity to ensure the hunt remains hyper focused on a specific activity, there are no metrics specified to determine when the goal is complete.

The hunt can strengthen this goal by adding criteria that would clearly define when the goal of the hunt has been accomplished.

Measurable: Detect successful exploitation of CVE-2021-26855 & CVE-2021-27065 via the Metasploit ProxyLogon RCE resulting in the introduction of a web shell through analysis of at least 7 days of file activity data of all Exchange servers in the XYZ North American domain.

Assessment: When setting this goal, the hunter must consider the likelihood of success based upon the measurements of success outlined in the goal. If the criteria listed in the goal creates an impossible situation for success, the hunter should revise the goal.

Achievable: Does the threat hunt team have access to 7 days' worth of file activity data for Exchange servers in the XYZ North American domain?

Assessment: The hunter now has an achievable goal that is measurable and using specific criteria however the threat hunter must still consider whether the goal is relevant to the organization and the threat hunting program's mission statement.

Relevant: Does the organization use Microsoft Exchange for email? Is the Exchange deployment on premises or in the cloud? If the organization uses Microsoft Exchange, are the servers patched? Are there existing automated detections designed to alert on the same behaviors specified in the goal? Is the threat hunting program responsible for hunting in the XYZ north American domain?

Assessment: Confirming the relevancy the hunter now possesses a well-structured goal however without including a time component, the goal risks losing any sort of urgency for completion.

Time-Based: By June 23, 2022 assess at least 7 days of file activity data of all Exchange servers in the XYZ North American domain for evidence of successful exploitation of CVE-2021-26855 & CVE-2021-27065 via the Metasploit ProxyLogon RCE resulting in the introduction of a web shell.

Example Threat Hunt

Remote Transfers using BITSAdmin

In Context of APT10

Document Control

Title	Remote Transfers using BITSAdmin
Created	2022-02-17
Document Version	0.1
Last Updated	
Document Owner	
Change Reviewers	

Revision History

Version	Date	Name	Changes

Goal

Detect malicious transfers associated with bitsadmins.exe being used to download content from a remote host residing outside of the <clients> network.

Hypothesis

Given an adversary leverages BITS to send or receive data with a local or remote host. When the bits job executes, a windows event log entry using EID 59/60 will be written containing the URL to the host.

Validate Data

- The detection of BITSAdmin requires the ingestion of WEL 59/60 in the BITS event log
  - EventID 59 - BITS started the <jobname> transfer job that is associated with http://example.com URL.
  - EventID 60 - BITS stopped transferring the <jobname> transfer job that is associated with the http://example.com URL. The status code is 0xxxx.
- 2021-12-14 BITS Windows event logs are currently not being ingested into the centralized SIEM. Threat Hunting team working with the security team to enable data logging and storage. Ticket Number 1234 has been created
- 2021-12-15 Ticket Number 1234 resolved. BITS Windows event log 59 and 60 is currently ingested into the centralized SIEM. Potential blind spots may occur within the organization that are related BITSAdmin process due to events only being ingested from the North American domain not the European.

Create Test Data

Validation for the BitsAdmin condition can occur by performing the following execution on a Windows system:

Bitsadmin.exe /create 1 bitsadmin.exe /addfile 1 https://live.sysinternals.com/autoruns.exe c:\data\playfolder\autoruns.exe bitsadmin.exe /RESUME 1 bitsadmin /complete 1

Define Hunt Strategy

Look for transfer jobs within the Microsoft-Windows-Bits-Client EventID 59. Identify URL that fall outside normal operation such as Google, Microsoft, Adobe, and WindowsLive. Additionally look for stopped transfer jobs within EventID 60, which also contains the URL and the object being transferred.

BITS stopped transferring the evil.png transfer job that is associated with the https://i.imgur.com/evil.png URL. The status code is 0x0.

Validate Hunt

- 2021-12-15 – Hunt has been tested against a small subset of data and test data has been found. 200 False positives discovered related to third party programs such as browsers. Baseline has been adjusted to filter unrelated data.
- 2021-12-15 Hunt has been tested against a small subset of data and test data has been found .50 False positives discovered related to known good processes. Baseline has been adjusted to filter unrelated data.
- 2021-12-22 – Hunt has been tested against a small test environment and test data has been found. False positives have not been discovered nor any hits for malicious activities
- 2022-01-22 – Hunt has been tested against a large test environment and test data has been found. 15 False positives discovered relating to program setup. Baseline has been adjusted to filter unrelated data
- 2022-02-22 – Hunt has been tested against a large subset of data in the environment and test data has been found. No false positives discovered, only test data remains. Able to be pushed to production.

Document Findings

- 2021-12-14 BITS Windows event logs are currently not being ingested into the centralized SIEM. Threat Hunting team working with the security team to enable data logging and storage. Ticket Number 1234 has been created
- 2021-12-15 Ticket Number 1234 resolved. BITS Windows event log 59 and 60 is currently ingested into the centralized SIEM. Potential blind spots may occur within the organization that are related BITSAdmin process due to events only being ingested from the North American domain not the European

- 2021-12-15 – Detection of possible malicious transfers identified on the hosts XFIR_Banshee
    - Ticket 778 has been created to research URL and consult with Admins to determine if the transfers are legitimate. bitsadmin /transfer myDownloadJob /download /priority normal https://downloadsrv/10mb.zip c:\\10mb.zip
    - Ticket 778 has been resolved. Determined as a false positive due to administrative activities.
    - Baseline has been tuned to adjust hunt. False positive has been documented.
- .
- 2021-12-15 – Ticket 123 has been submitted to SOC to convert this hunt into an automated detection.
- 2021-12-18 SOC has updated Ticket 123 with their ADS documentation for approval
- 2021-12-20 Hunt team approves SOC ADS
- 2021-12- 20 Hunt successfully converted to ADS on this date, with ticket 123. Hunt closed.

References

Phishing Campaign Leveraging BitsAdmin: https://unit42.paloaltonetworks.com/unit42-unique-office-loader-deploying-multiple-malware-families/

BITS used to download malware: https://www.secureworks.com/blog/malware-lingers-with-bits

https://isc.sans.edu/forums/diary/Microsoft+BITS+Used+to+Download+Payloads/21027/

https://marcoramilli.com/2018/08/31/hacking-the-hacker-stopping-a-big-botnet-targeting-usa-canada-and-italy/