|  |  |  |  |
| --- | --- | --- | --- |
| Incident Response –  Sample accident: Argous Co. | * Incidents can get complex very quickly * To illustrate this, we’ll look at a simple incident * Victim’s name is Argous (Fictitious for class purpose) * Threat actors are called Green Penguin * They are state-sponsored “Consultants” * Help avoid attribution to their sponsor. | 1 | 10 |
| Incident Response –  Webserver compromise | Related to the Argous incident. A Sys admin notified that some odd traffic on a CRM server. TCP port 4444 is listening and the process is called Office\_remoter.exe, and they also see a process called Office\_techneter.exe which makes periodic outbound connections to the Microsoft social.technet.microsoft.com server over TCP/443 port. Defender promptly kill these processes which is common thing to do. | 1 | 11 |
| CRM | Customer Relationship Management, web application that sales employees us both when on the road and while at the office. | 1 | 11 |
| Incident Response –  Reconnaissance:  Argous Example | Scanned the publicly accessible address space of Argous and discovered a firewall, the CRM web application, and the other servers on the internet-isolated network. In this instance the threat actors didn’t take many steps to ne stealthy, while they dis use a VPN to obscure their IPaddress, they scanning activity generated a handful of alerts n the firewall, the IP address of the VPN servers were known to be malicious. | 1 | 12 |
| Anonymity tools | Tools used to provide anonymity such hiding your IP address. | 1 | 12 |
| Threat intel information | Used to identify proxy servers that is used for malicious activity | 1 | 12 |
| Mistake #1 | Ignored firewalls alerts of pre-attack traffic | 1 | 12 |
| Mistake #2 | No threat intel about known malicious IP | 1 | 12 |
| Incident Response –  Scan and Exploit Web app | The SSRF vulnerability allowed threat actors to read the source code of the CRM application leading to the discovery of a command injection vulnerability. The command injection vulnerability gave the threat actors the ability to run arbitrary commands. Both vulnerabilities could be exploited without needed to log into the web application. | 1 | 13 |
| Mistake #3 | Failed to fix know server-side request Forgery (SSRF) and command injection vulnerabilities | 1 | 13 |
| SSRF – Server-side Request Forgery | Involves an attacker abusing server functionality to access or modify resources. | 1 | 13 |
| Incident Response –  Pivot and internal Scanning | The threat actors realized the CRM web app had both public and private facing IP address. This was done so both remote and local employees could access the CRM functionality. A proxy that listened on TCP port 4444 was downloaded and forwarded access to internal network allowing the threat actors to pivot and send tragic around the firewalls filtering mechanism. “ Office\_Remoter.exe. | 1 | 14 |
| Mistake #4 | Dual-home host allowed pivot around the firewall | 1 | 14 |
| Mistake #5 | No monitoring on the internal network | 1 | 14 |
| Incident Response – Lateral movement | The threat actors stared performing reconnaissance and scanning again from behind the firewall. After finding passwords were accessible, they were able to crack them and realized a database administrator who had local administration permissions reused his password, allowing the threat actors to pivot and gain control. | 1 | 14 |
| White papers |  | 1 | 15 |
| Mistake #6 | Easily cracked password | 1 | 15 |
| Mistake #7 | Password reuse from CRM to domain | 1 | 15 |
| Incident Response –  Domain password Access and Pivoting | Threat actors noticed there was a local account on each system with the same AssetMgtAcct. Focusing their attention this account, the used their local administrator privileges on the database server to extract the NT hashes from memory and cracked the password offline. | 1 | 16 |
| Mistake #8 | Asset mgt account had same password on all systems | 1 | 16 |
| Mistake #9 | No alerts for new software on critical systems | 1 | 16 |
| incident Response –  Establishing Persistence, command & Control | Even after killing the 2 processes found on the CRM server, Office Remoter (the proxy) and Ofice\_techneter (the c2 channel) the attackers still had malware installed on the 3 other systems, the CRM command injection n vulnerability, and the reverse TCP connections from the internal systems. | 1 | 17 |
| Mistake #10 | The victim failed to add filters to the firewall for the incoming traffic to the TCP port 4444. | 1 | 17 |
| Mistake #11 | Didn’t scan rest of network for indicators of compromise. | 1 | 17 |
| Incident Response: 6 steps  PICERL | Preparation, identification, containment, eradication, recovery, lessons learned | 1 | 18 |
| Preparation | Refers to activities an organization does before an incident occurs, this includes police procedure, implementing internal monitoring, security best practices, etc. | 1 | 18 |
| Identification | It could happen in many ways, such as customers calling about the “internet being down”, or maybe an IDS alert. This phase is known as “detection” | 1 | 18 |
| Containment | Once an incident has been identified, the next step is containment. Sometimes containment is divided into multiple actions: Short term followed by evidence collection, and long term (more invasive) containment once the evidence has been collected. | 1 | 18 |
| Eradication | Refers to undoing the damage the threat actors did | 1 | 18 |
| Recovery | Refers to the steps taken to get business systems back up and running. | 1 | 18 |
| Lessons learned | Is when the final report is written, and the vulnerabilities the threat actors exploited are fixed. | 1 | 18 |
| Incident Response –  Common Problems | * A deeper problem lies in a linear (static) approach to incident response. * Poor security hygiene (lack of visibility and threat intelligence) * Little scoping (if any) leads to complete containment (sometimes, they even skip this part completely) * Not fixing the vulnerabilities. * Failure to apply lessons learned by not identifying the root of the issue | 1 | 19 |
| Incident Response –  Best practices | * Principle of least privilege. * Strong passwords * Network monitoring * Log aggregation * Employing threat intelligence. | 1 | 19 |
| Dynamic Approach on Incident Response (DAIR) | There is no recipe for incident response, and a static or leaner approach just won work. Instead of thinking of incident response as phases or steps, it’s better to think in terms of waypoints, outcomes, and activities as shown in illustration on this page. | 1 | 20 |
| DAIR –  Preparation | 1. know thy organization  * What is important to the business? * What policies and procedures are in place?  1. Internal visibility is key for responding to incidents.  * This will often form the bulk of evidence during an investigation. * Network and host visibility are both important * Who reviews logs? How often? * Identifying existing sources and gaps can be an eye-opening exercise.  1. Have plans for recovering systems.  * Often, the most cost-effective way to eradicate rootkits is to rebuild. * Backups, backups, backups.  1. Prepare the IR team (training, practice, ethic obligations. | 1 | 21 |
| Internal logging mechanism | Internal IDS, Firewall logs, endpoint logs etc. | 1 | 21 |
| DAIR –  Detection | * Many possible sources for detecting an incident. * Network devices (firewalls, IDS) * Host logs (System logs, application logs) * Admins and users n noticing something isn’t right. * Threat intelligence feeds * Third-party notification * The first decision is always verification * Do you have an incident, or is it a false positive? * Sometimes easy, such as a website defacement * Sometimes difficult, requiring a full forensic examination. * It’s also a good idea to triage. * What type if incident is it? * Affects how you respond | 1 | 22 |
| Example: Application Log Detect | * This is login attempts from a WordPress app. * Application log in information * This could be an attack due to the 10 failed attempts. * Attacker may be using an anonymization tool to mas their identity. * We don’t know if this system is always this busy. We don’t have enough information to make this assertion. | 1 | 23 |
| Scoping | * Many incidents involve threat actors moving laterally, once behind the firewall, move to other systems. * Proper scoping is key, determining where threat actors are isn’t always easy. * Scope may change, scan the enterprise for known indicators of compromise. Not uncommon to find new IOCs during an incident. * Make full use of existing detection mechanisms, may also write scrips (or use tools) to scan. Use known IOCs to scan the rest of the organization throughout your investigation. | 1 | 24 |
| Velociraptor | * IR teams need scalable tools to conduct analysis on endpoints. * Velociraptor is a free tool from Velocidex. Agent software for Windows, Linux, macOS. Server software for data collection, analysis. * Easy to setup and deploy. * Asynchronous communication support. * Query file system registry: run remote commands, interrogate clients artifacts, all build on Velociraptor Query Language (VQL) | 1 | 25 |
| Velociraptor –  Notes | The Velociraptor agent is a VQL endpoint, allowing an admin to query systems to collect information. Velociraptor can be deployed quickly on select endpoints or run as an agent for always available interrogation. | 1 | 25 |
| Velociraptor – GUI | Interesting tool because we can look at the date stamp information and the name information, what processes and attacker used. This would help discovering IOCs on a compromise platform. | 1 | 26 |
| Containment | * Stop the threat actor from continuing to operate in the environment. * Requires proper scoping to be successful. * May help meet other goals such as eradication. * Containment may occur in multiple stages, like business decision or evidence collection. | 1 | 27 |
| Containment –  Activities | May include network isolation, patching, eliminating account or backdoor access, using network filtering devices, and manipulating DNS entries, the goal is to deny the attacker access through minimal change to systems | 1 | 27 |
| Eradication | * Undoing the threat actor actions, containment is about stopping their operations, eradication is about removing them.   Example activities:   * Restoring systems from trusted backups * Removing threat actor process, accounts. * Performing a vulnerability assessment.   May also help meet goals such a recovery:   * Dealing with fraudulent transactions. * Modified source code. | 1 | 28 |
| Recovery | * Business needs to get back up and running.   Rebuilding a system is often the most cost effective:   * Not always possible. * May consider shorter-term containment options as a band-aid to buy time.   Try to bring systems online during off-hours:   * Easier to monitor. * This is a business decision, and you may be overruled. | 1 | 29 |
| Remediation | Try to identify and fix the root cause.  Compromise due to a weak password:   * Why was the weak password allowed? * Can be difficult if multiple factors involved.   Closely monitor any compromised system:   * A rootkit and/or backdoor suggest intent to return. * Monitor network sensors, host, and application logs. * Look for incident-specific IOCs | 1 | 30 |
| Post-Incident | * Develop a final report. * Right after an incident, there is a lot of momentum, the impact fades over time.   Schedule a follow-up review:   * What has been implemented? * Has the organization been compromised again? Original compromise? * Timeframe varies, but 30, 60, and 90 – day increments are not uncommon. | 1 | 31 |
| Dynamic Approach on Incident Response (DAIR) |  | 1 | 32 |
| Visual summary: Incident Response |  | 1 | 33 |
| Live examination | A way to find compromised systems is there is no know signature or during an incident with known IOCs? In this case Network traffic can be very useful. However, not all malware generates traffic and encryption can make things difficult. | 1 | 35 |
| Microsoft PowerShell -Live examination | * Powerful command interpreter and scripting language. * Primarily windows but also available for UNIX systems. * Powerful pipelining capabilities, data access and filtering options. * Primary tool for host analysis. | 1 | 36 |
| Microsoft PowerShell -Live examination: Shortcomings | Powerful capabilities but limited introspection security risks, incomplete data access, steep learning curve, and a required change in how we think about working with data. | 1 | 36 |
| Examining Process: Live examination  PowerShell | * Get-Process: Get brief information about running processes * Get-Process ‘powersh\*’ : Get brief information about a named process with a wildcard. * Get-Process ‘powershell’ |Select-Object \* : Detailed information. * Get-Process -ComputerName SEC504STUDENT: Remote systems. | 1 | 37 |
| Get-Process | Foundational activity for examining a live system is to investigate running processes. Running it with no arguments will display several columns of information about the running processes. Doesn’t provide you information about the parent process. | 1 | 37 |
| Get-CimInstance Process Data: Live examination | CIM is the Common Information Model part of the windows management instrumentation (WMI) framework that lets us interrogate detailed information about the Windows host. | 1 | 38 |
| Get-CimInstance  Example | **PS C: \Users\Sec504> Get-CimInstance -Class Win32\_Process | Where-Object -Property ParentProcessID -EQ 644**   * **Get-CimInstance -Class Win32\_Process |** : Returns an object with Windows process information, start the PowerShell pipeline with | * **Where-Object :** Start a loop examining each process returned by Get-CimInstance. * **-Property ParentProcessID :** Create a filtering expression based on the ParentProcessID property value. * **-EQ 644 :** Display process where the ParentProcessId parameter is equal to 644. | 1 | 38 |
| Identifying Suspicious Process | Is it a new or unrecognized process?  Is the name random-looking?  Is it running from a non-standard path?  Is the parent suspicious?  Is the parent-child relationship suspicious?  Is it tied to suspicious activity?  Based 64 encoded command-line options?  These recommendations can identify suspicious process, but additional analysis is required to identify if the process is malicious. | 1 | 40 |
| EncodedCommand | Pay close attention to any running processes that have base64-encoded command-line options. Many attackers use PowerShell’s -EncodedCommand to specify the content of a script. Note that not every -EncodedCommand is suspicious, it is just worth to investigate. | 1 | 40 |
| CyberChef | Is useful for encoding and decoding any data, not just process-related information. | 1 | 41 |
| Examining Network Usage | Get-NetTCPConnection will display network connection information, including listening ports, bound ports (reserving a port number but not yet accepting connections), stablished connections, and several other statuses. It doesn’t not show the process name. | 1 | 42 |
| Get-Process -Is processed | This PowerShell command will retrieve both the network connection details and the process name in one command. | 1 | 42 |
| Get-NetTCPConnection | will display network connection information, including listening ports, bound ports (reserving a port number but not yet accepting connections), stablished connections, and several other statuses. It doesn’t not show the process name. | 1 | 42 |
| Identifying Suspicious Network Activity | Abnormal for the associated process   * Notepad making connections to port 80 * Service making multiple outbound connections (could be an updater)   Abnormal for the environment   * Lots of activity during off hours * Long running HTTP/HTTPS sessions * Beaconing   Technique-specific   * Lateral movement implies connections to other internal hosts   Know Malicious hosts/addresses   * Based on threat intelligence * From incident, or other processes/ connections ( i.e., pivoting) | 1 | 43 |
| Examining Services | Another live examination activity is to examine Windows services. Windows services are background tasks that are controlled through the windows services.exe process and can be confitures to start automatically. Attackers will often use Windows services as a persistence method, to gain continued access to a compromised system after reboot. We can use Get-Service followed by Get-CimInstance to get the running services and to retrieve additional information. | 1 | 44 |
| Get-Service | Is also used in a live examination to examine Windows services in the background. To obtain additional information: **Get-Service | Select-Object**. | 1 | 44 |
| Get-CimInstance | Is also used in a live examination to examine services because Get-Service will not provide sufficient information. Using it with -ClassName Win32\_service to get additional details about Windows services. | 1 | 44 |
| Registry Interrogation | Get-ChildItem: Like navigating a file system, we can examine the register using HKLM: or HKCU: prefix. Get-ItemProperty: For a given registry key, Examine the values. | 1 | 45 |
| Get-ChildItem | Can be used for registry interrogation. It is like navigating a file system, we can examine the register using HKLM: or HKCU: prefix. | 1 | 45 |
| Get-ItemProperty | Can be used for registry interrogation. For a given registry key, Examine the values. | 1 | 45 |
| Unusual Accounts | Get-LocalUser Get-LocalGroup Get-LocalGroupMember | 1 | 46 |
| Unusual Scheduled Tasks | Get-ScheduledTask : Look for unusual scheduled tasks. Get-ScheduledTaskInfo : Export scheduled task for command details. Export-ScheduledTask : Examine last run status. | 1 | 47 |
| Unusual Log Entries | Get-WinEvent | 1 | 48 |
| FilterHashTable | PowerShell. When you don’t need all the data, it helps you filter data. It is better than using Where-Object |. It gets event for a specific data range | 1 | 48 |
| Differential Analysis | Compare-Object Where we can take a list of known good services, take a list of current services, and then that will display all the things that changed and things that we need to investigate | 1 | 50 |
| PowerShell Cheat Sheet |  | 1 | 51 |
| PowerShell Legacy commands | It is Ok to continue using legacy commands to get the information you need to complete your analysis. When invoking legacy commands, specify .exe at the end of the command to avoid using PowerShell aliases with the same name. | 1 | 52 |
| Additional Supporting Tools | * The Sysinternals tools are excellent and free.   The center for internet security has templates that can be used and scoring tools that can be used with Windows. | 1 | 53 |
| Sysinternals tools | Suite of tools to add to your incident response and detection arsenal.   * **Process explorer**: detail information for running processes. * **Autoruns**: displays a comprehensive list of AutoStart extensibility points (ASEP) * **Process Monitor:** Shows file system, registry, network and process information in real time. * **Sysmom**: Collects detailed event information for system monitoring and analysis. * **TCPView:** Maps listening and active TCP and UDP activity to the associated applications. * **Procdump:** CLI tool to capture memory for a running process for analysis | 1 | 53 |
| Visual summary: Live Examination |  | 1 | 54 |
| Network Investigations | Network information can provide valuable insight into an investigation, it is not without challenges though and should be used to augment other analysis activities. | 1 | 59 |
| Network investigations:  Sources | * Network Traffic: live capture * Network Devices: Firewalls, proxies.   Host Devices: Windows event logs can create logs about the network’s interaction. | 1 | 59 |
| Network investigations:  Challenges | * Accessibility: Data Export. * Fidelity: Missing data.   Visibility: Encryption | 1 | 59 |
| Analyzing Packet Captures | Full packet capture is often considered a gold standard.   * Provides the lowest (practical) View of data, * Analysis and investigation can be done offline.   Still have limitations in practice   * Very large files. * Encryption can hinder analysis. * Application layer protocols not easily evaluated.   Two commonly used format.   * Pcap: Older format, widely supported.   Pcapng: extensible, advance features such as encryption, stored comments, improves timestamps resolution and more | 1 | 60 |
| Tcpdump | Its power comes from the ability to extract useful information quickly at the command line leading to opportunities for parsing the output with text processing tools and automating these tasks | 1 | 61 |
| Tcpdump | Command-line tool to capture and display network traffic.   * In widespread use for several decades and display network traffic.   Available on most environments and platforms.   * Unix-like (Linux, macOS, BSD) Windows (windump) * Even many embedded analyses.   Performs Basic protocols analysis.   * Interprets IP, TCP, UDP, ICMP, etc.   Includes powerful options for filtering. | 1 | 61 |
| Tcpdump options | * Tcpdump -i interface: Capture traffic for an interface. Can also use *any.* * Tcpdump -i interface -w file: Captures for an interface and write to a file. * Tcpdump -r file -n: Read packets from a file and don’t resolve hosts and ports.   Tcpdump -r file -n -A: read packets from a file, don’t resolve, show as ASCII | 1 | 62 |
| Berkeley Packet Filters (BPF) | Specialized language for filter packets.   * BPF expressions are composed of primitives and operators. * Primitives are composed of one or more qualifiers and an ID   Three kinds of qualifiers   * Type: what kind of ID is (host, net, port, or port range) * Dir: the direction (src, dst) * Proto: match a protocol IP, TCP. UDP, ICMP)   Can combine multiple primitives   * Using and (and, &&) or (or, ||) and not (not, !)   Parentheses to add precedence can also clarify intent. | 1 | 63 |
| Berkeley Packet Filters (BPF) Examples: | * tcpdump -r file ‘host 8.8.8.8’ : Traffic going or from host 8.8.8.8 * tcpdump -r file ‘src host 8.8.8.8’ : Traffic coming from host 8.8.8.8 * tcpdump -r file ‘not src host 8.8.8.8’ : Traffic where the src is not 8.8.8.8. * tcpdump -r file ‘icmp and (src host 8.8.8.8)’ : Only ICMP from 8.8.8.8 | 1 | 64 |
| Web Proxies | Many corporate environments use web proxies.   * A local cache can reduce bandwidth usage. * Can filter out sites inappropriate for business.   With the widespread use of web apps, web traffic is becoming more valuable to investigations.   * Build more through profile of user activity. * Identify anomalous / suspicious requests. * Potential to intercept SSL/TLS traffic.   Squid is a popular open-source web proxy other include, Blue coat, Forefront, TMG, etc. | 1 | 65 |
| Access Logs | Record individual requests   * User definable format, but default is quite verbose. * May or may not include URL, depending on configuration. | 1 | 66 |
| Visual Summary: Network Investigations |  | 1 | 67 |
| Memory Investigations (RAM investigations) | WinPmem: capture RAM in Windows   * Analyzing an image of RAM has become a staple of investigations * First, we need to collect memory (WinPmem) * Then we use the same strategies for examining memory images as on live systems. * identifying suspicious processes, network connections, etc. | 1 | 70 |
| Volatility Overview | * Volatility is a python framework for analyzing memory (first released in 2007, big update to version 3 in 2021) * Runs on Windows, macOS, Linux. * Analyzes Windows, macOS, Linux memory captures. * Specify a memory capture and a desired plugin for analysis. | 1 | 71 |
| Listing Processes | windows.pslist.PsList: this plugin lists processes, similar to how the operating system would using live analysis tools (like Get-Process). | 1 | 72 |
| Parent and Child Processes | windows.pstree.PsTree: this plugin lists the parent child relationship and it is represented by an \* and indentation. | 1 | 73 |
| Scanning for Network Connection | windows.netscan.NetScan: This plugin helps you investigate unexpected network listenners or connections. It is similar to the output of netstat, or Get-NetTCPconnection and Get-NetUDPEndpoint. | 1 | 74 |
| Process Command Line | windows.cmdline.CmdLine: this command line details reveals the location for the process executable and the command line arguments. | 1 | 75 |
| Volatility plugins: | *windows.dlllist.DllList*: List DDLs for processes.  *Windows.driverscan.DriverScan*: List kernel modules  *Windows.envars.Envars*: Lists environment variables  *Windows.filescan.FileScan*: Scan for files  *Windows.dumpfiles.DumpFiles*: Carve out files  *Windows.info.Info*: Examine Windows version information  *Windows.hashdump.HashDump*: Retrieve password hashes.  *Windows.privileges.Privs*: List privileges by process  *Windows.registry.hivelist.Hivelist:* List registry hive offsets  *Windows.registry.printkey.PrintKey*: Access keys with - - offset  *Windows.registry.userassist.UserAssist:* Enumerate programs run from start menu.  *Windows.registry.certificates.Certificates:* List trusted certificates in windows cert. store.  *Windows.svscan.SvcScan*: List service name, display name and PID. | 1 | 76 |
| Applying Memory Investigation | Memory investigation steps are similar to live investigation steps.   * We use volatility to analyze memory instead of PowerShell cmdlets.   The Analysis process starts with the EOI (event of interest)   * Suspicious process? Start with PSList and PsTree * Suspicious network listener? Start with NetScan, the move to processes. * Suspicious programs? Start with CmdLine, then processes. | 1 | 77 |
| Visual Summary: Memory Investigations |  | 1 | 77 |
| Malware Investigations | How to you know if an unknown program is evil?   * Suspicious isn’t necessarily malicious. * Oddly name executables aren’t enough, might still be benign.   How can you determine indicators?   * Someone might have reverse engineered it already * But not always .. and sometimes signatures change.   Malware investigations can also feed threat intelligence.  Two basic approaches   * Monitoring the environment: behavioral analysis. * Examining code: static analysis. | 1 | 81 |
| Online Analysis Sites | Online engine that performs various types of automated analysis and can save you a lot of time.  VirusTotal: will run a specimen through several antivirus engines, can you can purchase access to uploaded specimens.  Hybrid Analysis: has sandboxes that run malware and record activity. Can choose if sample should be shared with community, and offers a commercial onsite product. | 1 | 82 |
| Practicing Good Hygiene | Minimize attack surface for the malware.   * Don’t want to be the reason your organization is on the front page of the internet storm center.   Never EVER investigate malware on your day-to-day host…EVER.   * An air-gapped system that you wipe after each use is ideal.   More common to use a VM   * Use host-only (or equivalent) networking. * Enable firewalls and other measures on the host.   Options for transferring data: USB devices, temporarily-enables virtual machine folders. | 1 | 83 |
| Basic Attributes | One of the first things we need to do when investigating malware is to calculate a cryptographic hash sum.   * Get-FileHash file: Calculate the SHA256 hash of a file on Windows. * Strings file: View ASCII and 16-bit little endian Unicode strings. * $ strings file: view the ASCII strings on Linux. * $ strings -e l file: view 16-bit little endian Unicode strings on Linux. | 1 | 84 |
| Monitoring the Environment | You will often need to run through this strategy several times, changing the environment to meet the malware’s actions.  Monitoring the environment is a common strategy for investigating malware.  Basic strategy:   1. Get environment ready. 2. Take a VM snapshot (if applicable) 3. Enable monitoring tools. 4. Run malware. 5. Interact with malware (optional) 6. Kill malware (optional) 7. Pause monitoring tools. 8. Review output. | 1 | 85 |
| Snapshot vs Continuous Recording | A snapshot only sees the first and last event.  Some monitoring tools take snapshots of the environment.   * Take a snapshot before and after running the malware, and compare.   Others record continues changes/events.   * Start the tool before running the malware, and let it record.   Continues recording tools gather much more data and see things a snapshot might miss; this is also a drawback. | 1 | 86 |
| Regshot | Takes and compares a snapshot of the registry and optionally file system.  Provides summary of changes.   * What was added * What was removed * What changed   Process:   * 1st shot * Run malware (and optionally interact) * 2nd shot * Compare. | 1 | 87 |
| Regshot Output | Prefetch files can have useful evidence during an investigation, including when a program was most recently executed. | 1 | 88 |
| Process Monitor | Is a dynamic or continuous monitoring tool, it will record all registry, all file system, all network, all process even, and it could be turn on and off. | 1 | 89 |
| Summarizing Process Monitor Output | Even with filters, process monitor generates lots of output.  Can Focus on individual categories using buttons.  Basic summaries available under tools menu.   * Summarize various categories of activity. | 1 | 90 |
| Process tree | Process Monitor’s more useful summary tools. To get more details about a process, such as time it started, its command line, and optional exit time, just click on the process. It builds its tree based on captured events, we can see the process start and stop times, as well as detailed command line paremeters. | 1 | 91 |
| Analyzing Code | Often requires some knowledge of the target language.   * Even a little understanding goes a long way.   IDA PRO is the most well-known tool in this area.   * Both disassembler and debugger * Optional decompiler (Hex-Rays) * Commercial   Ghidra by NSA:  Open source, but has support for collaboration. It is pretty expensive. | 1 | 92 |
| Visual Summary: Malware Investigations |  | 1 | 93 |
| Cloud Investigations | How do we apply what we’ve learned about incident response to cloud systems?   * Complex technologies, rapidly changing * Even defining cloud can be difficult: infrastructure, platforms, software.   Cloud IR resembles on-premises IR; however, the tools and techniques are very different. | 1 | 96 |
| Security Responsibility Demarcation (IaaS, PaaS, SaaS) | All cloud provides have a shared responsibility model.  Responsible party changes with different products, even in same vendor.   * Container services vs. VMs vs. serverless vs. abstract services. * AWS EC2 vs LightSail, Google Computer vs Cloud Run.   See book for a more detailed description of the demarcation. | 1 | 97 |
| Preparation: Cloud IR Account Access | Conduct analysis in the cloud, matching the same region. Working where the data is will be much faster and less costly.  Prepare a cloud IR analysis workstation.  Ideal: Perform IR from a different service account.   * Same tasks performed with an in-cloud account. * Logging, host analysis, storage should an alternate cloud service account for isolation. | 1 | 98 |
| Preparation: Configuring Logging | For cloud systems, one of the major considerations for preparations is the configuration and deployment of logging systems. Important things to log.drtf   * API Access: Threat hunting, platform misuse. * Network Flow: Attack timeline identification, scoping. * Storage Requests, Responses: Assess data access, exfiltration, breach reporting. * Traffic mirroring: Detailed insight into network activity for analysis. * Verification of breach data access, threat hunting. | 1 | 99 |
| Logging | Chart | 1 | 100 |
| Detection: Cloud Analysis Tools | Once logging is configured for the cloud provider, we can start to apply detection and threat hunting using the cloud data. Preserving the idea that cloud IR is best done in the cloud, it is also best practice that the logging information be reviewed on a continual basis using cloud-provider analysis tools, augmented with manual analysis for a deeper inspection by the incident response analyst.  Threat detection uses endpoint data and cloud control plane data (API used to access cloud assets)   * AWS GuardDuty * Azure Sentinel * GCP CloudArmor | 1 | 101 |
| Containment: Isolate, Protect, Snapshot, Label | Cloud tools are well-designed to accommodate containment, labeling.   1. Detach and deregister instance from autoscaling or load balance groups. 2. Isolate the instance security group (ACL rules, isolated VPC) 3. Prevent accidental termination with termination protection. 4. Snapshot storage volumes, VM. 5. Add tags to show that the instance is under investigation.   These steps are primarily intended for infrastructure as a Service (IaaS instances but can also be applied to PaaS, SaaS services as well. For cloud PaaS infrastructure, we apply similar steps to the container as opposed to the virtual machine instance. | 1 | 102 |
| Containment: Data Collection with Storage | After creating an image, you can export the image to block storage for later analysis or use block storage on a live system as a detachable storage entity.s  aws ec2 describe-volumes aws ec2 attach-volume | 1 | 103 |
| Analysis: Cloud Logging Data, Dashboards | Like a webserver, S3 logs record user agent information and other useful content. S3logparse gathers useful data.  Some cloud analysts become frustrated because of the format and configuration of logging data is inconsistent. Fortunately, server tools are available to assist with manual review of logging information. Please see book for more details. | 1 | 104 |
| Response: Access Key Revocation | Very straightforward. To revoke someone’s keys, AWS users can visit the identity and Access Management (IAM) page in the AWS console and search by access key to identify the user associated with that key.  **Reset password twice for Azure AD** | 1 | 105 |
| Recovery and Remediation | Restore snapshots to known-good version based on log analysis timeline and understanding of the incident.  Review an audit access passwords, keys, tokens, roles, policies, groups, and permissions.   * Validate MFA (multi-factor authentication) for users * Verify policies and privileges are restricted to the minimum need for a job function.   Increase logging verbosity on target systems for extra visibility.  All API access, packet capture.  Remediation is often not fun of incident response but it is still vitally important. Critical analysis of access methods and change auditing are necessary to prevent recurring compromise. | 1 | 106 |
| Cloud IR - Additional Considerations | Foster data preservation with developers and cloud operations staff.   * Too often DevOps will terminate and restart to address a “bug”. * Eliminates important information about an incident.   IR in cloud will cost money (bandwidth, storage, instances)   * Get access and prior approval for this.   Establish support channel with cloud providers in advance (SLA capabilities)  Conduct tabletop exercises (see media files bonus module and lab) | 1 | 107 |
| Visual Summary: Cloud Investigations |  | 1 | 108 |
| **BOOK 2: RECON, SCANNING AND ENUMERATION ATTACKS**  **Hacker Tools, Techniques, and Exploits Introduction** |  |  |  |
| Purpose of This Course |  | 2 | 5 |
| Hacker | Is a highly intelligent individual who wants to explore technology to learn | 2 | 5 |
| Why We're Covering What We're Covering | Because they are widespread use right now, they provide us fundamental information about the principles the attackers employ. | 2 | 6 |
| Always Get Permission | * Full and documented permission is essential before you run any of these tools on a network. * When getting permission, it needs to be in writing. * The documented permission should also state that the giver of permission understands there may be potentially adverse side effects of the scanning or testing activity. | 2 | 7 |
| General Trends: Attack for Fun and Profit | Attackers are figuring out how to make money from their malicious code.  Ask law enforcement: If there’s money in a given crime, we’ll see much more of it.  How to make money on malicious code:   * Cryptocurrency miners * Spam and web-based advertising * Phishing: Email, phone, and targeted (spear) phishing. * Denial-of-service extorsion. * Keystroke loggers stealing financial information. * Rent out armies of infected systems for all the above. * Ram scrapers pulling CC numbers from POS terminals.   Ransomware. | 2 | 8 |
| General Trends: Consumer Device Attacks | * Internet of things devices are widespread in the home and in the enterprise. * Price competition between vendors and short time-to-market development cycles often produces lackluster security features. * Product adoption continues with little ability to manage devices on a large scale. | 2 | 9 |
| General Trends: The Golden Age | Attackers are growing in sophistication but so are defenders.  More scientific and precise approaches to defense, costly breaches have produced top-level support for infosec skills. Knowing systems and networking is good and adding infosec skills differentiates you from your peers. | 2 | 10 |
| **MITRE ATT&CK Framework** | Is a not -for-profit US company managing technical Federally Funday Research and Development Centers (FFRDCs)  ATT&CK Framework is a knowledge base, mapping adversary tactics, techniques, and procedure (TTPs), based on real-world observations.  ATT&CK integrates a common nomenclature for attacks. | 2 | 12 |
| MITRE ATT&CK Framework | Attacker TTPs are complex and difficult to characterize comprehensively. ATT&CK provides an easy framework to characterize and cross-reference attack techniques to gain better insight into how attackers operate, and how to defend networks. | 2 | 12 |
| MITRE ATT&CK (Enterprise Matrix) |  | 2 | 13 |
| How we integrate SEC504 with ATT&CK | Content is normalized using the nomenclature conventions adopted by ATT&CK.   * This gives you a consistent framework to work from when describing documenting, and discussing attacker tactics, techniques, and procedures.   Cross-reference tools and techniques with ATT&CK identifiers.   * Let’s talk about password spray attacks (credential Access: TA0006) * “Donut injects shellcode into existing assemblies and payloads” (Process Injection: T1055)   Validation for attack tool and defense realism. | 2 | 14 |
| MITRE ATT&CK References | Attack techniques and tactics are categorized with the MITRE ATTACK Id in the top right.  Notes pages provide reference links for techniques and tools. | 2 | 15 |
| **Open-Source Intelligence** | OSINT | 2 | 17 |
| Reconnaissance | The internet is a treasure trove of information for a curious attacker.  Reconnaissance is building intel, looking for opportunities.  Two general types of attackers   * Non discriminating attackers: Look for low-hanging fruit, and my skip this step (musabetsu-kougeki) * Attackers out to get a particular site: this step is extremely important.   Helpful step for experience attackers.  Reconnaissance usually begins with OSINT collection. | 2 | 17 |
| Open-Source Intelligence | Before sending your first packet to a target, you should collect OSINT data.  All organizations have lots of data online.  Planned sharing: Hacker email addresses for | 2 | 18 |
| Certificate Transparency: The New WHOIS |  | 2 |  |
| OSINT Data Collection |  | 2 |  |
| Not OSINT Data |  | 2 |  |
| Visual Summary: Open-Source Intelligence | nslookup dig | 2 |  |
| **DNS Interrogation** | nslookup server 81.4.108.41 settype=AXFR ls -d zonetransfer.me tcp/port 53 | 2 |  |
| DNS Interrogation | dig @81.4.108.41 AXFR zonetransfer.me | 2 |  |
| DNS Zone Transfer in Windows | sudo nmap --script dns-brute | 2 |  |
| DNS Zone Transfer in UNIX | whois | 2 |  |
| DNS Automated Interrogation | crt.sh | 2 |  |
| DNS Reconnaissance Defenses |  | 2 |  |
| Visual Summary: DNS Interrogation |  | 2 |  |
| **Website Reconnaisance** |  | 2 |  |
| Website Reconnaisance |  | 2 | 39 |
| Exiftool | Exiftool | 2 | 40 |
| Website Crawl and Wordlist Generation: CeWL | CeWL | 2 | 41 |
| Reconnaisance with Search Engines | Google Dorks  Google Hacking Database | 2 | 42 |
| Other Website Information |  | 2 | 43 |
| Web-Based Recon/Attack Tools | www.shodan.io www.network-tools.com  viewdns.info www.securityspace.com | 2 | 44 |
| Website Reconnaisance Defenses | robots.txt | 2 | 46 |
| Visual Summary: Website Reconnaisance | Exiftool | 2 | 47 |
| **Network and Host Scanning with Nmap** |  | 2 |  |
| Network Mapping with Nmap |  | 2 | 49 |
| Sweeping for Network Mapping | ICMP Echo Request  TCP SYN to port 43  TCP ACK to port 80  ICMP Timestamp Request | 2 | 50 |
| Nmap Host Discovery | sudo nmap -sn 0.0.0.0 | 2 | 51 |
| Closer Look at the IP Header |  | 2 | 52 |
| How Traditional Traceroute Works | sudo nmap -sn --traceroute | 2 | 53 |
| Port Scanning |  | 2 | 56 |
| TCP and UDP Ports |  | 2 | 57 |
| TCP Three-Way Handshake |  | 2 | 58 |
| Nmap: Scan Types |  | 2 | 59 |
| Nmap NSE Scripts |  | 2 | 61 |
| Visual Summary: Nmap |  | 2 | 63 |
| **Cloud Spotlight: Cloud Scanning** |  | 2 |  |
| Cloud Spotlight: Cloud Scanning |  | 2 | 66 |
| JQ and JSON Data |  | 2 | 67 |
| Cloud Scanning Process |  | 2 | 68 |
| Exhaustive IP Address Enumeration |  | 2 | 69 |
| Scanning Large Ranges: Masscan | Masscan awk | 2 | 70 |
| Masscan Scan of AWS us-east-1 |  | 2 | 71 |
| Attributing Hosts |  | 2 | 72 |
| TLS-Scan | TLS-Scan | 2 | 73 |
| Interpreting TLS-Scan Results |  | 2 | 74 |
| Other Scanners: EyeWitness |  | 2 | 75 |
| Cloud Scanning Defense |  | 2 | 77 |
| Visual Summary: Cloud Scanning |  | 2 | 79 |
| **SMB Security** |  | 2 |  |
| SMB Security | TCP port 445 | 2 | 82 |
| SMB Security Features |  | 2 | 83 |
| SMB Shares | Get-WmiObject (WMI)  net.exe (Windows an non-Windows) | 2 | 84 |
| Searching for SMB Shares: SMBeagle | SMBeagle | 2 | 85 |
| SMB Share Data Harvesting, Search |  | 2 | 86 |
| SMB Access: The Linux Way | smbclient | 2 | 87 |
| Using Samba's rpcclient from Linux for More Info | rpcclient | 2 | 88 |
| SMB Exploits |  | 2 | 89 |
| SMB Password Attacks |  | 2 | 90 |
| Identifying and Dropping SMB Sessions | Get-SmbSession Net use | 2 | 91 |
| Preparation: Defenses Against Evil SMB Sessions | Block access to TCP/445,135,137,139 UDP/445,137,138 | 2 | 93 |
| Visual Summary: SMB Attacks |  | 2 | 94 |
| Defense Spotlight: DeepBlueCLI | useful, not perfect | 2 | 98 |
| DeepBlueCLI Capabilities |  | 2 | 99 |
| DeepBlueCLI Metasploit Attack Detection |  | 2 | 101 |
| DeepBlueCLI Non-Malicious Event |  | 2 | 102 |
| DeepBlueCLI Output Formatting |  | 2 | 103 |
| Conclusion |  | 2 | 104 |
| Visual Summary: DeepBlueCLI |  | 2 | 105 |
| Password Guessing Attacks |  | 3 | 4 |
| Password Guessing Alternative: Password Spraying |  | 3 | 5 |
| THC Hydra Password Guessing | Hydra | 3 | 6 |
| Password Guess Selection |  | 3 | 7 |
| Credential Stuffing |  | 3 | 8 |
| Visual Summary: Password Attacks |  | 3 | 10 |
| Microsoft 365 Password Attacks |  | 3 | 13 |
| Microsoft 365 Authentication API |  | 3 | 14 |
| MSOLSpray | invoke-MSOLSpray | 3 | 15 |
| Azure Smart Lockout |  | 3 | 16 |
| AWS API Gateway |  | 3 | 17 |
| FireProx and MSOLSpray | invoke-MFASweep | 3 | 18 |
| MFA Bypass and Microsoft 365 |  | 3 | 19 |
| Microsoft 365 Incident Response: Identification | Account license downgrade: Get-MsoUser | 3 | 20 |
| Visual Summary: Microsoft 365 Password Attacks |  | 3 | 21 |
| Understanding Password Hashes |  | 3 | 24 |
| Windows LANMAN Hashes |  | 3 | 25 |
| NT Hashes |  | 3 | 26 |
| Password Hashes without Salt |  | 3 | 27 |
| Password Salting |  | 3 | 28 |
| Obtaining Windows Domain Controller Hashes | ntdutil secretsdump.py | 3 | 29 |
| Obtaining Windows 10 Password Hashes | Reads password hashes from memory. Migrate to lsass.exe, then dump hashes. Ps -S lsass.exe migrate 620 hashdump | 3 | 31 |
| Recognizing Windows Hashes | LANMAN: aad3b435b51404 NTHASH: 31d6cfe0d16ae93 | 3 | 32 |
| UNIX and Linux Passwords |  | 3 | 33 |
| Decoding UNIX/Linux Password Hashes |  | 3 | 34 |
| Hashing Rounds | MD5: 1000 rounds | 3 | 35 |
| Password Hashing Rounds | SHA256-512: 5000 rounds | 3 | 36 |
| Mitigating GPU-Based Password Cracking |  | 3 | 37 |
| Visual Summary: Understanding Password Hashes |  | 3 | 38 |
| Password Cracking |  | 3 | 41 |
| John the Ripper | sudo unshadow /etc/passwd /etc/shadow > combined    john combined | 3 | 42 |
| John's Cracking Modes |  | 3 | 43 |
| John's Input and Output | cracked passwords stored in john.pot | 3 | 44 |
| John Sample Session |  | 3 | 45 |
| Hashcat Hash and Cracking Support |  | 3 | 46 |
| Hashcat Attack Modes | Mass attack mode = Brute-force | 3 | 47 |
| Hashcat Attack Modes - By Example | Combinator mode (-a 1) uses 2 wordlists | 3 | 48 |
| Hashcat Mask Attack |  | 3 | 51 |
| Hashcat Rules |  | 3 | 55 |
| Preparation: Disable LANMAN Authentication |  | 3 | 56 |
| Preparation: Password Complexity Tools |  | 3 | 57 |
| Deploy Multi-factor Authentication |  | 3 | 58 |
| Visual Summary: Password Cracking |  | 3 | 59 |
| Cloud Spotlight: Insecure Storage |  | 3 | 63 |
| Cloud Storage Access | https://s3.amazonaws.com/BUCKETNAME  https://www.googleapis.com/storage/v1/b/BUCKETNAME https://ACCOUNTNAME.blob.core.windows.net/CONTAINERNAME | 3 | 65 |
| Storage Scanning: AWS S3 | cat words  bucket\_finder.rb words --download | 3 | 66 |
| Storage Scanning: Google Cloud Bucket | gcpbucketbrute.py -u -k falsimentis gsutil ls gs:/falsimentis-dev | 3 | 67 |
| Azure Scanning: Basic Blob Finder | cat namelist  basicblobfinder.py namelist | 3 | 68 |
| What's the Big Deal? A Walkthrough | *Listable: enumerate and download Writable: upload* | 3 | 69 |
| Bucket Discovery: Creative Name Selection |  | 3 | 72 |
| Scanning Your Own Organization |  | 3 | 73 |
| DNS Logs, HTTP Proxy, Network Logs |  | 3 | 74 |
| The Need for Cloud Storage Logging |  | 3 | 75 |
| Visual Summary: Cloud Storage |  | 3 | 76 |
| Netcat |  | 3 | 79 |
| Netcat Client Mode | Standard Error (stderr) | 3 | 80 |
| Netcat Listen Mode |  | 3 | 81 |
| Some Netcat Uses |  | 3 | 82 |
| Netcat: Data Transfer |  | 3 | 83 |
| Netcat: Port Scanning |  | 3 | 84 |
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| Netcat: Persistent Backdoor Listeners |  | 3 | 86 |
| Netcat: Relays |  | 3 | 87 |
| Make a Netcat Relay on Linux |  | 3 | 88 |
| Netcat: Defense |  | 3 | 89 |
| Netcat: Closing |  | 3 | 90 |
| Visual Summary: Netcat |  | 3 | 91 |
| The Metasploit Arsenal |  | 4 | 6 |
| Metasploit User Interfaces |  | 4 | 7 |
| Exploits Currently Included Metasploit Framework |  | 4 | 8 |
| Payloads Included in Metasploit Framework |  | 4 | 9 |
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| Visual Summary: Metasploit Framework |  | 4 | 13 |
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| Drive-By Attack Operation |  | 4 | 17 |
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| Code-Executing Microsoft Office Files |  | 4 | 20 |
| Conventional Exploit Delivery |  | 4 | 23 |
| Fake Installers |  | 4 | 24 |
| Browser Exploitation Framework (BeEF) |  | 4 | 25 |
| Building Payloads - Metasploit MSFVenom |  | 4 | 27 |
| Drive-By Attack Defense |  | 4 | 30 |
| Visual Summary: Drive-By Attacks |  | 4 | 31 |
| Defense Spotlight: System Resource Usage Monitor Dum |  | 4 | 34 |
| SRUM Data Storage |  | 4 | 35 |
| SRUM-Dump Auto Extract |  | 4 | 37 |
| Visual Summary: System Resource Usage Monitor |  | 4 | 40 |
| Command Injection |  | 4 | 43 |
| Identifying Command Injection Vulnerabilities |  | 4 | 44 |
| More than a Web Vunerability |  | 4 | 45 |
| Command Injection Defenses |  | 4 | 48 |
| Visual Summary: Command Injection |  | 4 | 49 |
| Cross-site Scripting |  | 4 | 53 |
| Attack Opportunity |  | 4 | 54 |
| Stored Cross-site Scripting Attack |  | 4 | 55 |
| Reflected Cross-site Scripting Attack |  | 4 | 56 |
| Reflected XSS Phishing Link Example |  | 4 | 57 |
| What can an Attacker Do With XSS |  | 4 | 58 |
| Testing for XSS |  | 4 | 59 |
| Cross-site Scripting Defense |  | 4 | 60 |
| Visual Summary: Cross-site Scripting |  | 4 | 62 |
| Structured Query Language |  | 4 | 67 |
| Injecting SQL Content |  | 4 | 68 |
| SQL Union Statement |  | 4 | 70 |
| UNION Select Results |  | 4 | 71 |
| Sqlmap |  | 4 | 72 |
| Importan Sqlmap Notes |  | 4 | 73 |
| Sqlmap Enumeration |  | 4 | 74 |
| Cloud SQL Does Not Escape Vunerability |  | 4 | 76 |
| SQL Injection Testing Risk |  | 4 | 77 |
| SQL Injection Defenses |  | 4 | 78 |
| Visual Summary: SQL Injection |  | 4 | 79 |
| Cloud Spotlight: SSRF and IMDS |  | 4 | 83 |
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| Instance Metadata Service (IMDS) Access |  | 4 | 90 |
| AWS IMDSv1 Credential Exfiltration |  | 4 | 91 |
| Cloud IMDS Access |  | 4 | 92 |
| SSRF and Cloud Target Access |  | 4 | 93 |
| Defending Against SSRF and IMDS Attacks |  | 4 | 94 |
| Visual Summary: SSRF and IMDS |  | 4 | 95 |
| Post-Exploitation Topics |  | 5 | 5 |
| Endpoint Security Bypass |  | 5 | 6 |
| DefenderCheck | **DefenderCheck.exe .\mimikatz.exe**  **Uses a high/low strategy, splitting the file into pieces and scanning repeatedly until the smallest data chunk is found that triggers a threat alert.** | 5 | 7 |
| Evation through Code wrapping and Obfuscation |  | 5 | 8 |
| Application Allow Lists |  | 5 | 9 |
| Living Off the Land (LOL) | Reuses tools and ultilities already permitted on the target system | 5 | 10 |
| Microsoft.NET InstallUtil | shellcode.exe  InstallUtil /U shellcode.exe | 5 | 11 |
| Endpoint Bypass: Defenses | -Current version EDR   * Allow list execution control with AppLocker or third party tools * Threat hunt for execution failures   UEBA logging and monitioring | 5 | 12 |
| Visual Summary: Endpoint Security Bypass |  | 5 | 13 |
| Pivoting and Lateral Movement |  | 5 | 17 |
| Meterpreter Pivoting | portfwd | 5 | 18 |
| Meterpreter ROUTE Pivoting | route add 10.10.10.10/34 1 set RHOST 10.10.10.100 exploit | 5 | 19 |
| Host Discovery and Post Scanning | run arp\_scanner -r 10.10.10.0/24  background  route add 10.10.10.0/24 1 use auxiliary/scanner/portscan/tcp set RHOSTS 10.10.10.1,11,100 set PORTS 22,25,80,135,445,631 run | 5 | 20 |
| LOL - SSH Port Forwarding | ssh -L 8000:10.10.10.100:80 victortimko@10.10.10.11 | 5 | 21 |
| LOL - Port Forwarding with netsh | netsh interface portproxy add v4tov4 listenaddress=0.0.0.0 listenport=8000 connectaddress=10.10.10.100 connectport=80 netstat -nato | findstr:8000 | 5 | 22 |
| Pivoting for Lateral Movement |  | 5 | 23 |
| Visual Summary: Pivoting and Lateral Movement |  | 5 | 24 |
| Hijacking Attacks | LLMNR Link-Local Multicast Name Resolution Responder | 5 | 27 |
| Responder Starting |  | 5 | 28 |
| Responder Capture |  | 5 | 29 |
| Defenses | Disable LLMNR  Private VLANs  UEBA | 5 | 30 |
| Visual Summary: Hijacking Attacks |  | 5 | 31 |
| Establishing Persistence | Regain access/Avoid detection/Preserve privileges/Flexible in reestablishing access | 5 | 34 |
| Create Account | meterpreter> execute -f "net user /add assetmgtacct Att@ckerPssw" execute -f "net localgroup administrator /add assetmgtacct" execute -i -f "net user" | 5 | 35 |
| Services | **msf6> use exploit/windows/local/persistence\_service** | 5 | 36 |
| VMI Event Subscription | mofcomp vmi.mof  use exploit/windows/local/wmi\_persistence | 5 | 37 |
| Active Directory Persistence: Golden Ticket | "-Attacker compromises DC  -Retrieves krbtgt user password (root of trust) hash  -Forges Ticket Granting Ticket using hash (Mimikatz/Impacket)  -Authenticates to any Kerbero service"  -> Token (ticket or certificate) | 5 | 39 |
| Web Shells |  | 5 | 41 |
| Cloud Persistence | aws iam list-users  awis iam list-access-key --user-name jsmith aws iam create-access-key --user-name jsmith | 5 | 42 |
| Persistence Defense | Get-WMIObject -Namespace root\Subscription -Class\_EventFilter | fl -property query | 5 | 43 |
| Persistence - Takeaway |  | 5 | 44 |
| Visual Summary: Establishing Persistence |  | 5 | 45 |
| Defense Spotlight: RITA | Use statistical threat identification to analyze data over time for threat hunting, used for offline network activity assessment (reads from Zeek logging data). Works best with data over one or more days  No packet payload content analysis | 5 | 49 |
| Fundamentally Different Network Behavior |  | 5 | 50 |
| Beacon Analysis |  | 5 | 52 |
| Long Connections | rita show-long-connection -H mynetwork | head -15 | 5 | 53 |
| DNS Analysis | rita show-exploded-dns mynetwork | head -15 | 5 | 54 |
| RITA is a Threat Hunting Tool | config.yaml | 5 | 55 |
| Visual Summary: RITA |  | 5 | 56 |
| Data Collection and Exfiltration |  | 5 | 59 |
| Linux Password Harvesting |  | 5 | 60 |
| Sudo Privileges | sudo -l sudo gdb -q  shell id | 5 | 61 |
| Windows Passwords: Mimikatz | .\mimikatz.exe  .\procdump64.exe -accepteula -ma lsass.exe lsass.dmp | 5 | 62 |
| Password Managers and Clipboard Access |  | 5 | 64 |
| Data Collection Defenses | Limit and monitor network access  Network monitoring tool  Application allow list  SRUM data | 5 | 65 |
| Visual Summary: Data Collection |  | 5 | 66 |
| Cloud Spotlight: Cloud Post-Exploitation | cat .aws/credentials | 5 | 68 |
| Attacker Situation Report | aws sts get-caller-identity | 5 | 69 |
| Privilege Escalation Attacks |  | 5 | 70 |
| Pacu: AWS Interrogation and Attack Framework | Metasploit for AWS  ./cli.py  import\_keys jmerckle run iam\_enum\_permission run iam\_privesc\_scan | 5 | 71 |
| More Privilege, More Data | gcloud sql instance\_list | 5 | 72 |
| Microsoft 365 Compliance Search |  | 5 | 74 |
| Cloud Post-Exploitation Defenses |  | 5 | 75 |
| AWS: CloudMapper | cloudmapper.py prepare --config config.json --account acctname | 5 | 76 |
| ScoutSuite (AWS, GCP, Azure) |  | 5 | 77 |
| Cloud Logging |  | 5 | 78 |
| Visual Summary: Cloud Exploitation |  | 5 | 79 |
| Where To Go From Here |  | 5 | 82 |
| The Forgetting Curve |  | 5 | 83 |
| Spaced Repetition |  | 5 | 84 |
| Optimizing Review Intervals |  | 5 | 85 |
| Anki |  | 5 | 86 |
| Retention vs Certification |  | 5 | 87 |
| Certification: Use the Practice Exam Wisely |  | 5 | 88 |
| GCIH Practical Exam: CyberLive |  | 5 | 89 |
| Taking the Test |  | 5 | 90 |
| Why Do We Care |  | 5 | 91 |