Security Alerting and Monitoring

Concepts, Tools, and Best Practices

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March 11, 2025

Security Alerting & Monitoring: Protecting Digital Assets in Real-Time

- **Security monitoring** is the continuous observation of systems, applications, and networks to detect security events.
- Effective monitoring enables organizations to identify and respond to threats before significant damage occurs.
- Modern security requires 24/7 vigilance across increasingly complex digital environments.
- The goal is to maintain visibility into all security-relevant activities across the enterprise.

Key Concept

Security monitoring is not a one-time setup but a continuous process that requires regular assessment and refinement.

Lesson Overview: What We'll Cover

- We will explore the fundamental components of security monitoring infrastructure.
- You will learn how to implement effective security alerting mechanisms that balance sensitivity with precision.
- This leson covers both technical tools and organizational processes needed for security operations.
- By the end, you'll understand how to build and maintain a comprehensive security monitoring program.

Technical Focus

- Monitoring tools
- Log analysis
- Alert configuration
- Vulnerability scanning

Process Focus

- Response workflows
- Remediation procedures
- Documentation
- Continuous improvement

Introduction to Security Monitoring: Why It Matters

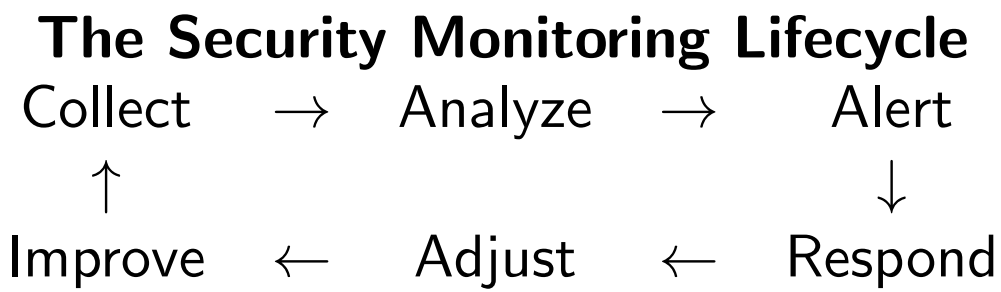
- Security breaches cost organizations an average of $4.45 million per incident (2023 data).
- Most successful attacks go undetected for over 200 days without proper monitoring.
- Regulatory requirements (GDPR, HIPAA, PCI-DSS) mandate security monitoring and incident reporting.
- Early detection through monitoring significantly reduces the impact and cost of security incidents.

Real-World Example

A major retailer detected unusual database query patterns through their monitoring system, identifying an active breach targeting customer payment data before any information was exfiltrated.

The Security Monitoring Lifecycle

- The **security monitoring lifecycle** is a continuous process of collection, analysis, alerting, and improvement.
- Data collection forms the foundation, gathering information from diverse sources across the enterprise.
- Analysis transforms raw data into actionable security intelligence through correlation and context.
- Response and remediation close the loop by addressing identified threats and vulnerabilities.



Monitoring Computing Resources: The Big Picture

- **Computing resources** include all digital assets an organization relies on to conduct business.
- Comprehensive monitoring requires visibility into systems, applications, and infrastructure components.
- The scale of modern environments necessitates automated monitoring solutions with intelligent filtering.
- Different resources require different monitoring approaches based on their criticality and vulnerability profile.

Monitoring Layers

Layer	Examples
Systems	Operating systems, endpoints, servers
Applications	Web apps, databases, custom software
Infrastructure	Networks, cloud services, IoT devices

Systems Monitoring: Critical Components

- **Systems monitoring** focuses on operating systems, host-based activities, and endpoint behaviors.
- Key indicators include user authentication events, privilege escalation, and unauthorized software execution.
- Host-based intrusion detection systems (HIDS) monitor for changes to critical system files and configurations.
- Endpoint detection and response (EDR) solutions provide detailed visibility into endpoint activities.

Critical System Events to Monitor

Always prioritize monitoring for account creation, privilege changes, security policy modifications, and unusual process execution patterns.

Application Monitoring: Protecting Software Assets

- **Application monitoring** focuses on the behavior and security of software running in your environment.
- Applications generate valuable security data through their logs, transaction records, and error messages.
- Web applications require special attention due to their exposure to external threats and common vulnerabilities.
- Database activity monitoring helps detect unauthorized access to sensitive information.
- Key application monitoring points:
  - Authentication attempts (successful and failed)
  - Authorization decisions and access control events
  - Input validation failures and unexpected exceptions
  - Changes to application configurations or permissions

Infrastructure Monitoring: Networks, Servers, and Beyond

- **Infrastructure monitoring** covers the foundational hardware, networking, and services supporting IT operations.
- Network traffic analysis helps identify communication patterns that may indicate compromise or data exfiltration.
- Server performance metrics can reveal resource exhaustion from denial-of-service attacks or crypto-mining malware.
- Cloud infrastructure requires specialized monitoring approaches due to its dynamic and distributed nature.

Infrastructure Monitoring Example

A sudden increase in outbound traffic during non-business hours from a server with no scheduled maintenance or backup activities warrants immediate investigation, as it may indicate data exfiltration.

Log Aggregation: Centralizing Security Data

- **Log aggregation** is the process of collecting log data from disparate sources into a central repository.
- Centralized logging provides a unified view of security events across the organization's entire environment.
- Without aggregation, security teams must manually check multiple systems, making correlation nearly impossible.
- Effective log aggregation preserves the original context and timestamps while normalizing formats for analysis.

Log Aggregation Benefits

- Faster incident detection and investigation
- Improved correlation of related events
- Simplified compliance reporting
- Preserved evidence for forensics

EXAMPLE: Log Aggregation in Practice

- Consider a potential account compromise scenario spanning multiple systems.
- Without log aggregation, these events appear as isolated incidents on different systems.
- With centralized logging, the pattern becomes clear: a coordinated attack targeting a specific user.
- The timeline view reveals the attack progression and enables rapid response.

Time	Source	Event	Details
09:42:15	VPN Server	Failed login	Username: jsmith, IP: 185.22.xx.xx
09:43:28	VPN Server	Failed login	Username: jsmith, IP: 185.22.xx.xx
09:47:02	Email Server	Password reset	Username: jsmith
09:51:37	VPN Server	Successful login	Username: jsmith, IP: 185.22.xx.xx
09:54:18	File Server	Access attempt	High-value financial documents

Table: Centralized View of Account Compromise Attack

Effective Alerting Strategies: When and How

- **Alerting** is the mechanism for notifying security personnel when suspicious or malicious activity is detected.
- Good alerts are actionable, contain relevant context, and include clear severity classifications.
- Alert fatigue occurs when too many notifications overwhelm analysts, causing important alerts to be missed.
- Tiered alerting routes different severity levels to appropriate personnel through different channels.

Alert Design Principles

Every alert should answer: What happened? Where did it happen? When did it happen? What is the potential impact? What action should be taken?

EXAMPLE: Crafting Actionable Security Alerts

- Compare these two alerts for the same security event.
- The improved alert provides context, impact assessment, and recommended actions.
- Including relevant data within the alert reduces investigation time.
- Standardized alert format ensures consistent interpretation and response.

Poor Alert:
"Multiple authentication failures detected for admin account."

Effective Alert:
"CRITICAL: Brute force attack detected"
Target: admin@company.com
Source: 5 different IPs, all from country X
Impact: Potential admin account compromise
Action: Block IPs and verify account status

Security Scanning: Proactive Defense

- **Security scanning** is the systematic examination of systems and networks to identify vulnerabilities.
- Regular scanning helps organizations discover weaknesses before they can be exploited by attackers.
- Authenticated scans (with credentials) provide deeper visibility than unauthenticated scans.
- Scan results should be prioritized based on vulnerability severity, asset criticality, and exploit availability.

Scanning Types

- **Vulnerability scanning**: Identifies known security weaknesses
- **Configuration scanning**: Validates security settings against baselines
- **Compliance scanning**: Checks adherence to regulatory requirements
- **Web application scanning**: Tests for web-specific vulnerabilities

Creating Effective Security Reports

- **Security reporting** transforms monitoring data into actionable insights for different stakeholders.
- Technical reports provide detailed findings for security teams to address specific vulnerabilities.
- Executive reports summarize security posture, trends, and risk levels for leadership decision-making.
- Compliance reports demonstrate adherence to regulatory requirements and security standards.

Report Type	Audience	Key Elements
Operational	Security analysts	Detailed technical findings, remediation steps
Tactical	Security managers	Trends, resource needs, program effectiveness
Strategic	Executives	Risk levels, business impact, investment needs
Compliance	Auditors	Control effectiveness, policy adherence

Table: Security Reporting Framework

Data Archiving: Retention Policies and Compliance

- **Security data archiving** preserves historical security information for investigations and compliance.
- Retention policies must balance storage costs with security and regulatory requirements.
- Different data types may require different retention periods based on their value and compliance needs.
- Archived data must remain searchable and retrievable while maintaining its integrity and chain of custody.

Common Retention Requirements

Financial institutions often must retain security logs for 7 years under various regulations, while healthcare organizations following HIPAA typically maintain security records for 6 years from creation or last effective date.

Alert Response Fundamentals: The First 15 Minutes

- **Alert response** is the process of investigating and addressing security notifications in a timely manner.
- The first 15 minutes are critical for containing potential damage and preserving evidence.
- Triage determines whether an alert represents a true security incident or a false positive.
- Having documented response procedures speeds reaction time and ensures consistent handling.

Initial Response Checklist

1. Acknowledge the alert and confirm receipt
2. Validate the alert is a genuine security concern
3. Assess the potential scope and impact
4. Initiate containment if an active threat is confirmed

Alert Tuning: Reducing False Positives

- **Alert tuning** is the ongoing refinement of detection rules to improve accuracy and relevance.
- False positives waste analyst time and contribute to alert fatigue, reducing overall security effectiveness.
- Tuning requires balancing sensitivity (not missing threats) with precision (avoiding false alarms).
- Keep a record of tuning changes to maintain awareness of detection coverage and potential blind spots.

Alert Tuning Approaches

- **Thresholding**: Adjusting when alerts trigger based on frequency or magnitude
- **Contextual filtering**: Adding business context to reduce noise (e.g., maintenance windows)
- **Whitelisting**: Explicitly excluding known-good activities from generating alerts
- **Correlation rules**: Requiring multiple conditions before alerting

Security Content Automation Protocol (SCAP): Standards-Based Security

- **SCAP** is a suite of specifications that standardize the format and nomenclature of security information.
- SCAP enables automated vulnerability management, measurement, and policy compliance checking.
- The protocol facilitates interoperability between security tools from different vendors.
- SCAP components include vulnerability naming (CVE), configuration checklists (XCCDF), and scoring (CVSS).

Key SCAP Components

- **Common Vulnerabilities and Exposures (CVE)**: Standard identifiers for known vulnerabilities
- **Common Configuration Enumeration (CCE)**: Identifiers for system configuration issues
- **Common Platform Enumeration (CPE)**: Standard naming of platforms and products
- **Common Vulnerability Scoring System (CVSS)**: Standardized severity scoring

Security Benchmarks: Establishing Baselines

- **Security benchmarks** are consensus-based configuration guidelines for securing systems and software.
- Benchmarks provide a baseline security standard against which systems can be measured and hardened.
- Organizations like CIS (Center for Internet Security) maintain benchmarks for various operating systems and applications.
- Automated tools can check systems against benchmarks to identify security configuration gaps.

Benchmark Example: Password Policy

A benchmark might specify:

- Minimum password length: 12 characters
- Complexity requirements: Upper/lowercase, numbers, symbols
- Maximum age: 90 days
- Account lockout: 5 failed attempts

Agent vs. Agentless Monitoring: Pros and Cons

- **Agent-based monitoring** installs software directly on monitored systems to collect and report security data.
- **Agentless monitoring** gathers information remotely without requiring software installation on target systems.
- The choice between approaches depends on security requirements, performance impact, and deployment complexity.
- Many organizations use a hybrid approach, applying each method where it makes the most sense.

Factor	**Agent-Based**	**Agentless**
Visibility	Deep system access	Limited to exposed interfaces
Performance	Local resource usage	Network bandwidth usage
Deployment	Installation required	Simpler deployment
Maintenance	Regular updates needed	Minimal maintenance
Coverage	Works offline	Requires network connectivity

Table: Agent vs. Agentless Comparison

Security Information and Event Management (SIEM): Comprehensive Monitoring

- **SIEM** systems collect, normalize, analyze, and correlate security data from across the enterprise.
- SIEM platforms combine security information management (SIM) with security event management (SEM).
- Modern SIEM solutions incorporate threat intelligence to identify sophisticated attacks and advanced threats.
- Key capabilities include real-time monitoring, incident management, and compliance reporting.

Core SIEM Functions

- **Data aggregation**: Collecting security data from diverse sources
- **Correlation**: Connecting related events to identify attack patterns
- **Alerting**: Notifying security teams of suspicious activities
- **Dashboards**: Visualizing security status and trends
- **Compliance**: Automating regulatory reporting requirements

EXAMPLE: SIEM Dashboard Analysis and Interpretation

- SIEM dashboards present security information visually for rapid understanding and action.
- This example dashboard highlights key security metrics that security teams monitor daily.
- Correlation across different metrics often reveals security incidents that individual alerts might miss.
- Trend analysis helps distinguish between normal variations and genuine security concerns.

SIEM Dashboard Metrics

Metric Category	**Key Information**
Threats by Source	Internal (27%), External (73%)
Alert Priority Distribution	Critical (12), High (47), Medium (156), Low (238)
Top Attack Vectors	Phishing, Credential Abuse, Malware, Web Attacks
System Coverage	98% of critical assets, 87% of all assets monitored

Antivirus Integration with Monitoring Systems

- **Antivirus (AV) solutions** detect and block malicious software using signatures and behavioral analysis.
- Modern endpoint protection platforms (EPP) extend beyond traditional AV to include additional security controls.
- Integration with monitoring systems allows centralized visibility into malware detections across the enterprise.
- Correlating AV alerts with other security data helps identify sophisticated attacks that use malware components.

Beyond Traditional Antivirus

Modern endpoint security has evolved beyond signature-based detection to include behavior monitoring, exploit prevention, machine learning, sandboxing, and rollback capabilities to better detect and respond to advanced threats.

Data Loss Prevention (DLP): Protecting Sensitive Information

- **Data Loss Prevention (DLP)** systems monitor, detect, and block sensitive data from leaving the organization.
- DLP solutions classify data based on content, context, and defined policies to prevent unauthorized disclosure.
- Monitoring points include network traffic, endpoints, email, cloud services, and storage systems.
- DLP generates alerts when sensitive data appears in unauthorized locations or is being transmitted insecurely.

DLP Use Cases

- Preventing employees from emailing sensitive customer records
- Blocking unauthorized transfers of intellectual property to external devices
- Detecting unencrypted transmission of regulated data (PII, PHI, PCI)
- Alerting when classified documents are stored in unapproved cloud services

SNMP Traps: Network Device Monitoring

- **Simple Network Management Protocol (SNMP) traps** are alerts sent from network devices to management systems.
- Traps provide real-time notification of significant events like interface status changes or threshold violations.
- Security-relevant SNMP traps include authentication failures, configuration changes, and hardware failures.
- SNMP monitoring helps detect physical layer attacks and infrastructure issues that impact security.

Common Security-Relevant SNMP Traps

- **coldStart**: Device has reinitialized (potential unauthorized reboot)
- **warmStart**: Device has reloaded without configuration change
- **linkDown/linkUp**: Network interface status changes
- **authenticationFailure**: Invalid SNMP community string attempts
- **egpNeighborLoss**: Routing peer relationship changes

NetFlow Analysis: Detecting Unusual Traffic Patterns

- **NetFlow** is a network protocol that collects IP traffic information and monitors network flow.
- NetFlow data provides visibility into "who is talking to whom" without capturing actual packet contents.
- Analyzing flow data helps identify anomalous communication patterns indicative of data exfiltration or C2 traffic.
- NetFlow monitoring requires less bandwidth and storage than full packet capture while providing valuable security insights.

NetFlow Security Applications

NetFlow analysis can detect data exfiltration (unusual outbound transfers), command and control communications (regular beaconing to unusual destinations), internal reconnaissance (port scanning), and denial of service attacks (traffic spikes).

NetFlow Analysis: Sample Command and Data

- Analyzing NetFlow data with nfdump to identify unusual outbound transfers:

```
$ nfdump -R /var/netflow/data -o extended -s dstip/bytes \
  'src net 10.0.0.0/8 and dst net not 10.0.0.0/8 and bytes > 10000000'

Date flow start       Duration Proto   Src IP:Port      Dst IP:Port      Bytes
2025-03-11 02:14:45   1823.5   TCP     10.5.4.23:49321  185.142.56.34:443   1.4G
2025-03-11 02:17:12   1738.1   TCP     10.5.4.23:49325  185.142.56.34:443   1.1G
2025-03-11 03:42:18    914.2   TCP     10.3.2.56:51432  91.213.89.75:22    478.5M
```

Suspicious Activity

Large data transfers to unusual destinations during off-hours require immediate investigation as potential data exfiltration.

Vulnerability Scanning: Finding Weaknesses Before Attackers

- **Vulnerability scanning** systematically checks systems for known security weaknesses.
- Regular scans provide visibility into the organization's security posture and potential exposure to attacks.
- Scan results should be prioritized based on vulnerability severity, asset value, and exploitability.
- Continuous vulnerability management integrates scanning, prioritization, remediation, and verification.

Types of Vulnerability Scanners

- **Network scanners**: Identify open ports, services, and network-level vulnerabilities
- **Web application scanners**: Test for OWASP Top 10 vulnerabilities like SQL injection
- **Database scanners**: Check for database-specific misconfigurations
- **Cloud configuration scanners**: Identify insecure cloud service settings

Vulnerability Scanner: Sample Output

- Vulnerability scanners provide detailed findings for each identified issue:

```
Finding: CVE-2024-8901
Host: web-server-04.example.com (10.10.14.22)
Severity: CRITICAL (CVSS: 9.8)
Description: Remote code execution vulnerability in
            Apache Tomcat 8.5.x < 8.5.97
Recommendation: Update to Tomcat 8.5.97 or later
Evidence: Server header reveals Tomcat 8.5.82
Exploitability: Public exploit available
References: https://nvd.nist.gov/vuln/detail/CVE-2024-8901
```

Important

Critical vulnerabilities with public exploits should be remediated within 24 hours according to our security policy.

Conclusion: Building a Comprehensive Security Monitoring Strategy

- Effective security monitoring requires a layered approach integrating multiple tools and techniques.
- People, process, and technology must work together to create a resilient security monitoring program.
- Start with high-value assets and critical systems, then expand monitoring coverage methodically.
- Continuous improvement through testing, tuning, and adaptation is essential as threats evolve.