Web Application Incident Response & Forensics: A Whole New Ball Game!

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Intrepidus Group

Company Overviews

- MANDIANT
  - Full spectrum information security company: Professional Services, Government Services, Education, and Software
  - Services include Application Security, Network Security, Incident Response, Computer Forensics
  - Offices in Alexandria, VA and NYC
- Intrepidus Group, Inc.
  - Network and Application Security Specialists
  - Offices in Chantilly, VA and NYC

Why Are We Here?

- "They" say that attacks against web applications are on the rise
- "We" see it – 70% of the attacks we have responded to in the last year have been against web applications
- Responding to such attacks is different
  - Need to understand application security
  - Need to look elsewhere for evidence

Agenda

- Background
- How web application incident response and forensics is different
- Case Studies
- Log discovery, review, and analysis
  - Web Server
  - Application Server
  - Database
- Remediation

Background


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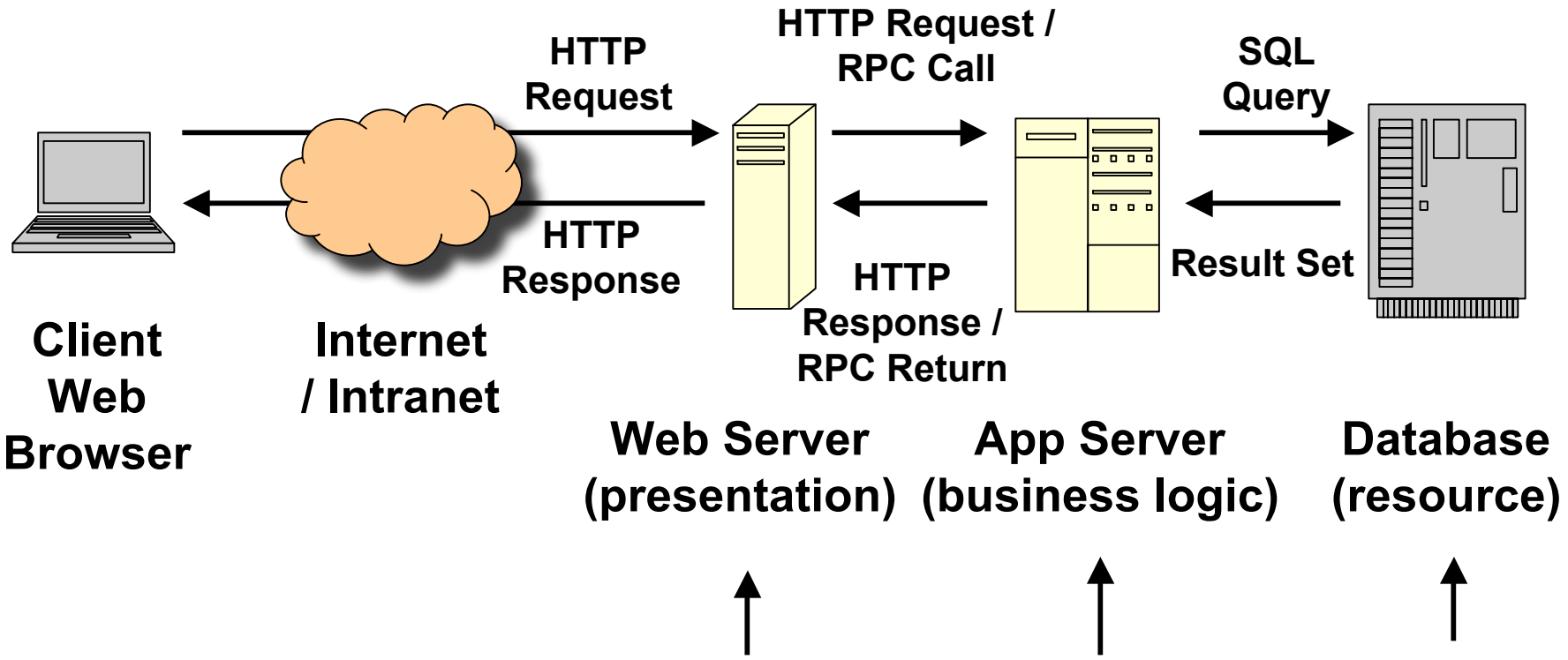
Three Tier Web Application



Standard Incident Response & Forensics

- Capture volatile data
  - Processes
  - Ports and network connections
  - Memory dumps
  - Logged in users
- Perhaps capture some non-volatile data
  - Event logs
  - File listing and timestamps
- Shutdown system
- Make forensic image

Standard Incident Response & Forensics

- Analyze image with forensic tools
  - Examine file timestamps
  - Check for known malicious software
  - Examine deleted files
  - Conduct string searches
  - Carve files based on headers

How Does Web App Forensics Differ?`

Let's find out…

Why Standard Process Doesn't Work

- Web applications are often distributed across multiple servers
- Web applications are often business critical and downtime for imaging may not be allowed
- Database servers usually have large disk arrays
- Web application attacks usually do not leave evidence in the same places as other attacks
- Web application forensics and incident response requires a solid understanding of web application security issues – not a conventional "forensicator" skill

Web Application Forensics Overview

- Understand the “normal” flow of the application
- Review log files:
  - Web Server
  - Application Server
  - Database Server
  - Application
- Capture application and server configuration files
- Identify potential anomalies:
  - Malicious input from client
  - Breaks in normal web access trends
  - Unusual referrers
  - Mid-session changes to cookie values
- Determine a remediation plan

A Report from the Trenches - Case #1

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Symptoms

- “I see a trade executed from my account …10000 shares of a company I haven’t even heard about, were purchased on January 17 (2006) @ 2 pm from my account!” – a client of a well-established brokerage firm in NYC.

- 7 other clients of the same brokerage firm report the same issue – in January 2006.

Investigation

- Computer security breaches were the prime suspect.
- Was the brokerage firm hacked? Was it the end user who was hacked?
- We had dates and times of the trade executions as a clue.

Investigation

- Our team began reviewing the brokerage firm's online trading application for clues
  - Network logs
  - Web server logs
  - Security mechanisms of the application

- We asked to duplicate the victim's hard drive and review it for indicators of compromise.

Web Server Logs

- Requested IIS logs for January 17, 2006 from all the (load balanced) servers.
- Combined the log files into one common repository = 1 GB
- Microsoft's Log Parser to the rescue

Microsoft LogParser

- LogParser is an excellent and free tool for analyzing log files
- Available from www.microsoft.com
- More information on unofficial LogParser support site: http://www.logparser.com/
- Supports a variety of log formats
- Uses SQL syntax to process log files

Microsoft LogParser

- Parsed out all requests to execute.asp using Microsoft Log Parser:

```
LogParser -o:csv "select * INTO
 execute.csv from *.log where
 cs-uri-stem like '/execute.asp%'"
```

Can You Find The Smoking Gun?

#Software: Microsoft Internet Information Services 5.0

#Version: 1.0

#Date: 2006-01-017 01:03:15

#Fields:time	c-ip	cs-method	cs-uri-stem	cs-uri-query	Status	version
1:03:15	172.16.22.33	POST	/execute.asp	sessionid=90198e1525e4b03797f833ff4320af39	200	HTTP/1.0
1:04:35	172.16.54.33	POST	/execute.asp	sessionid=3840943093874b3484c3839de9340494	200	HTTP/1.0
1:08:15	172.16.22.33	POST	/execute.asp	sessionid=90198e1525e4b03797f833ff4320af39	200	HTTP/1.0
1:10:19	172.16.87.231	POST	/execute.asp	sessionid=298230e0393bc09849d839209883993	200	HTTP/1.0
1:13:15	172.16.22.33	POST	/execute.asp	sessionid=90198e1525e4b03797f833ff4320af39	200	HTTP/1.0
1:18:15	172.16.22.33	POST	/execute.asp	sessionid=90198e1525e4b03797f833ff4320af39	200	HTTP/1.0
1:19:20	172.16.121.3	POST	/execute.asp	sessionid=676db87873ab0393898de0398348c89	200	HTTP/1.0
1:21:43	172.16.41.53	POST	/execute.asp	sessionid=3840943093874b3484c3839de9340494	200	HTTP/1.0
1:23:16	172.16.22.33	POST	/execute.asp	sessionid=90198e1525e4b03797f833ff4320af39	200	HTTP/1.0
1:28:15	172.16.22.33	POST	/execute.asp	sessionid=90198e1525e4b03797f833ff4320af39	200	HTTP/1.0
.	.	.	.	.	.	.
.	.	.	.	.	.	.

Next Step

- Noticed repeated use of same sessionid at regular intervals from the same IP
- Parsed out all requests with the suspicious sessionid

```
LogParser -o:csv "select * INTO
 sessionid.csv from *.log where
 cs-uri-query like
 '%90198e1525e4b03797f833ff4320af39'"
```

Can You Find The Smoking Gun?

#Software: Microsoft Internet Information Services 5.0

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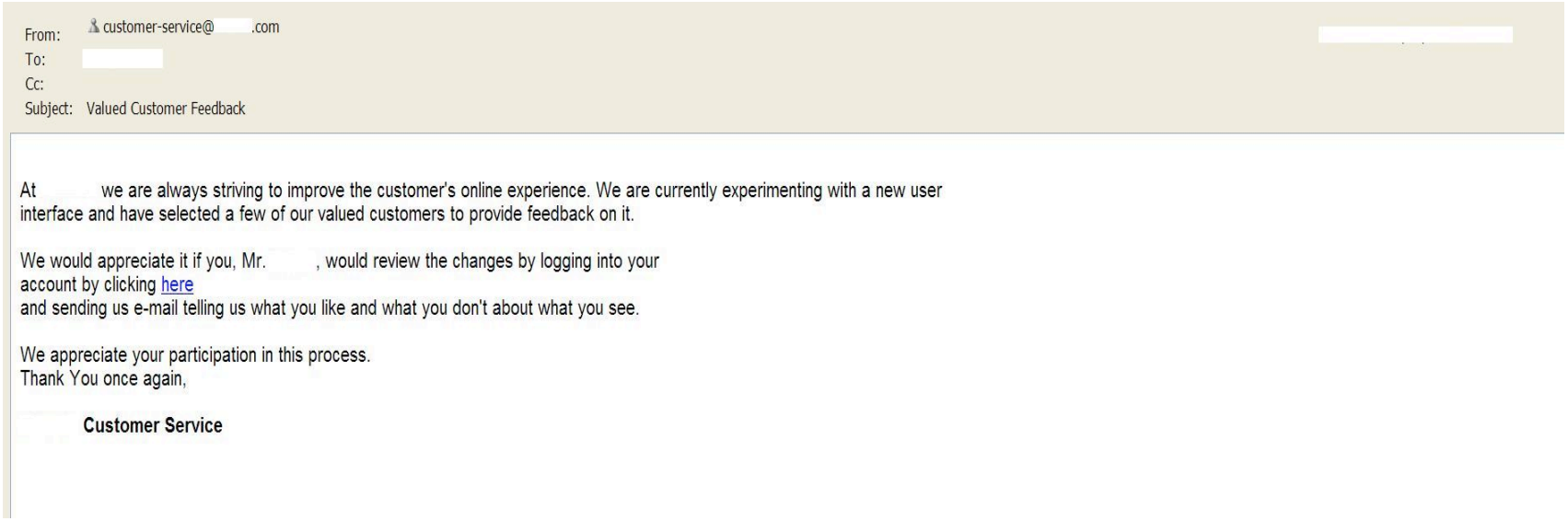
1:08:15	172.16.22.33	POST	/execute.asp	sessionid=90198e1525e4b03797f833ff4320af39	200	HTTP/1.0
1:13:15	172.16.22.33	POST	/execute.asp	sessionid=90198e1525e4b03797f833ff4320af39	200	HTTP/1.0
1:18:15	172.16.22.33	POST	/execute.asp	sessionid=90198e1525e4b03797f833ff4320af39	200	HTTP/1.0
1:23:16	172.16.22.33	POST	/execute.asp	sessionid=90198e1525e4b03797f833ff4320af39	200	HTTP/1.0
1:28:15	172.16.22.33	POST	/execute.asp	39	200	HTTP/1.0
.	.	.	.	.	.	.
.	.	.	.	.	.	.
13:53:15	172.16.22.33	POST	/execute.asp	sessionid=90198e1525e4b03797f833ff4320af39	200	HTTP/1.0
13:58:15	172.16.22.33	POST	/execute.asp	sessionid=90198e1525e4b03797f833ff4320af39	200	HTTP/1.0
14:03:15	172.16.22.33	POST	/execute.asp	sessionid=90198e1525e4b03797f833ff4320af39	200	HTTP/1.0
14:07:23	172.16.14.166	POST	/login.asp	sessionid=90198e1525e4b03797f833ff4320af39	200	HTTP/1.0
14:07:54	172.16.14.166	POST	/account.asp	sessionid=90198e1525e4b03797f833ff4320af39	200	HTTP/1.0
14:08:15	172.16.22.33	POST	/execute.asp	sessionid=90198e1525e4b03797f833ff4320af39	200	HTTP/1.0
14:10:09	172.16.22.33	POST	/confirm.asp	39	200	HTTP/1.0

Phishing?

- No indications of key logging trojans, malware, viruses, etc. were found on the victim's computer.
- Look what we found in the archived .pst file:



From: customer-service@ .com
To:
Cc:
Subject: Valued Customer Feedback

At we are always striving to improve the customer's online experience. We are currently experimenting with a new user interface and have selected a few of our valued customers to provide feedback on it.

We would appreciate it if you, Mr. , would review the changes by logging into your account by clicking here
and sending us e-mail telling us what you like and what you don't about what you see.

We appreciate your participation in this process.
Thank You once again,

Customer Service

URL: https://www.xyzbrokerage.com/login.asp?sessionid=90198e1525e4b03797f833ff4320af39

Session Fixation

- The application was confirmed to be vulnerable to session fixation:
  - A session id was issued before login
  - The same session id was used by the application after login for the purposes of user authorization
  - This allowed an attacker to hijack legitimate user sessions using a bit of social engineering

Web Server Logs

Caveat Responder

- Log file names and locations in this presentation are the default for the most common version and configuration of the software discussed
- Default file names and locations will vary depending on the specific version and configuration of the software
- Most applications allow the log file name and location to be changed
- Whenever possible, ask the system administrator for log locations

IIS 6.0

- Default logs are plain text in W3C Extended log file format
- Logs stored in LogFiles\W3SVCx
- Easily parsed with text parsing tools or with LogParser
- Log files can capture cookies and referrer headers
- Still missing key HTTP POST data

IIS 6.0 – Logged by Default

- Date / Time
- Client IP
- Server Info
- HTTP Method
- URL and Parameters
- HTTP Status Code
- User Agent

IIS 6.0 – Not Logged by Default

Can be enabled:

- Transfer Sizes
- Host Header
- Cookies
- Referrer

Not even an option…

- POST Data

Why Do We Care About POST Data?

- Much of the user input to a web application is passed to the server as POST parameters
- Manipulating these parameters is the prime mechanism for attacking an application
- POST data logging provides insight into such attacks
- POST data is necessary to perform an accurate damage assessment

Cookie Crunching

- May 2006
- Multi-national food and beverages company requested bids for a machinery maintenance contract
- The bids were to be provided over the Web
- One of the bidders appeared to have inside knowledge
- Chief counsel ordered an investigation

Cookie Crunching

- Application authorized requests based on the “uid” cookie
- Reviewed IIS 6.0 server logs
- Server was configured to log cookies
- Parsed all requests to bid.aspx
- Multiple requests from the same IP address with different uid cookies
- Whois on the IP address revealed the culprit
- Cookie logging saved the day!

Referrer Header

- What is the Referrer Header?
- Referrer headers are an indicator of browsing flow
- Can be used to identify abnormal browsing trends that may be indicative of an attack
- Not a reliable measure
- Referrer spoofing is easy and results in false positives

URLScan

- URLScan is a free IIS filter from Microsoft that can prevent some types of HTTP requests from making it to the web server
- If URLScan is in use, the logs will include details on blocked requests
- Logs are stored by default in same directory as URLScan
- Automated attacks can often be detected by reviewing URLScan logs

Apache Web Server Logs

- Log format and locations are highly customizable
- Log configuration set in httpd.conf
- Access log – records all requests
  - access.log on Windows, access_log on Unix
- Error log – holds diagnostic and error messages
  - error.log on Windows, error_log on Unix
- Some modules have their own logs:
  - rewrite.log

Apache Logs – Default Access Log

- LogFormat "%h %l %u %t \"%r\" %>s %b"
  - Remote Host
  - Remote logname (from identd)
  - Remote user (from HTTP authentication)
  - Time
  - First line of request
  - Status
  - Bytes sent
- mod_log_config can used to enhance Apache logging to capture additional fields

Application Server Logs

Application Server Logs

- Application servers will log data
- Logged events will include:
  - Unhandled application exceptions
  - Application errors
  - Loader problems (references to classes that are not available)
  - Other implementation dependent items
  - Some messages from applications

ASP.NET Application Server

- ASP.NET does not maintain its own log files
- Errors and unhandled exceptions are logged to the Windows event logs
- In .NET 2.0, an unhandled exception will halt the application by default

BEA WebLogic

- BEA WebLogic is a common Java application server and HTTP server
- Maintains a variety of logs:
  - Server Log
    - Messages and errors from the server, applications and subsystems
    - DOMAIN_NAME/servers/SERVER_NAME/logs/SERVER_NAME.log
  - Domain Log
    - Messages forwarded from the servers in the domain
    - Not all messages are forwarded or logged at the domain level
    - DomainName.log

BEA WebLogic

- Other logs that may be present:
  - HTTP Log – similar to Apache access log, can be named with sequence number or timestamp for log rotation
  - Node Manager Log – NM_HOME/nodemanager.log
  - Node Manager Server Instance Log – DOMAIN_NAME/servers/SERVER_NAME/logs/SERVER_NAME.out
  - Standard Output and Standard Error
    - Messages from the server and also from the applications
    - Not enabled by default
    - No default filename
  - Java Transaction API (JTA) Logs (*.tlog)
  - Java Database Connectivity (JDBC) Log (jdbc.log)

WebSphere Application Server

- IBM's WebSphere Application Server is another common Java App Server
- Logs created by WebSphere:
  - Apache Web Server Logs
    - Access Log
    - Error Log
  - IBM Service Log
    - Logs events for servers under a node
    - File name is activity.log
    - Log is binary data – use showlog script to convert

WebSphere Application Server

- Stream logs on WebSphere:
  - JVM logs – streams from Java code
    - SystemOut.log
    - SystemErr.log
  - Process logs – streams from native code
    - native_stdout.log
    - native_stderr.log

A Report from the Trenches - Case #2

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Symptoms

- The CEO of a retail organization received an extortion threat of $250,000 via snail mail
- The threat – 125,000 customer credit card numbers would be sold to the mafia
- The response was demanded in the form of a footer on the main page of the retailer's website

Response

- In-house counsel used several ploys to buy time – a mere 72 hours were granted by the extorter
- 3 members of our team were brought in to investigate round the clock for the next 3 days
- Our job was to determine how the credit card database may have been compromised and more importantly who was the culprit

What Followed?

- Frenzied web server log analysis to detect anomalous activity – Nothing!
- Reviewed all employee email inboxes to detect internal fraud – Nothing!
- Database login/logout activity reviewed – nothing suspicious
- Web application scanned for SQL injection flaws – No luck!
- Last resort – application code review

Racing Against Time

- Over 100,000 lines of code
- A comprehensive code review was ruled out
- Resorted to scripted searches through code

Scripted Searches

- Did the code contain raw SQL statements?
- Searched for occurrences of the “SELECT” in the code

  Regex = `.*SELECT.*`

- The search resulted in an overwhelming number of hits

Scripted Searches

- The results from the previous search were searched for occurrences of the “SELECT *” string to identify SQL statements where the scope was not properly limited

  Regex = **`SELECT \*.*FROM.*`**

- The search resulted in 5 hits
- One of the hits was:

```
SELECT * FROM CardTable
```

The Code That Made The Call

```
NameValueCollection coll = Request.QueryString;
String[] arr1 = coll.AllKeys;
...
String[] arr5 = coll.getValues(arr1[4]);
string extra = Server.HtmlEncode(arr5[0]).ToString();

if (extra.Equals("letmein"))
{
  Cmd = "SELECT * FROM CardTable";
}

...
```

Eureka!

- This was a backdoor – an insider job?
- Reviewed code archives to detect addition of code
- The first check-in with this code was made by a developer contracted from a third-party in Asia
- Found the URL with the additional parameter in the web server logs
- The client IP traced back to Asia!

Another One Bites The Dust…

- The development company was notified of this rogue activity
- Local law enforcement was cooperative

Post Mortem

- What could have been done better:
  - Encryption of sensitive info in the DB
  - More advanced DB logging
  - Security reviews of code

Database Server Logging

Database Server Logging

- Common databases have little or no logging enabled by default
- Logging of additional database events can be enabled
- Table or data specific logging can be accomplished with database triggers

MS SQL Server Database Logging

- Captures login/logout and other activity in the Windows Application Log
- ErrorLog file – server errors and other messages
  - Stored in \Mssql\Log
  - New log created on DB startup named ErrorLog
  - By default, 6 previous logs are stored with names ErrorLog.1 (most recent) to ErrorLog.6 (oldest)
- Server-Side Traces can be used for fine-grained auditing

MS SQL C2 Auditing – Advantages

- Records detailed information
  - Execution of stored procedures
  - Creation or deletion of objects like tables
  - Querying of tables
  - Permission changes
- Logs stored in .trc files that can be viewed using SQL Server Profiler
- Log files named audittrace_*.trc in the database data directory

MS SQL C2 Auditing – Disadvantages

- Databases and audit logs share the same directory
- C2 auditing affects SQL server performance
- If the disk is full and C2 log cannot be written SQL server execution is halted
- C2 auditing is not practical as a long-term solution

Oracle Database Auditing

- Events logged to the OS log by default:
  - Instance startup and shutdown
  - Connections to DB with administrator privileges
- Additional auditing of database events can be enabled
- Additional audit entries can be stored in a database table or in the OS Log

Oracle Database Alerting

- Alert.log
  - Flat text file
  - Records important information about the database operation
  - Records errors
  - References to trace files and dump files
- Trace files can result from:
  - An error in a background process
  - Administrator action

Application Logging

Application Level Logging

- Application logs can provide key information
  - Detailed knowledge of business logic
  - Good signal to noise ratio
- Ask developers or administrators:
  - Where are application logs?
  - What is format?
  - What messages would result from likely malicious activity?
  - How long are logs stored?

Application Level Logging

- Application should log these events:
  - Invalid Input
    - SQL Injection Attempts
    - Cross Site Scripting Attempts
  - Failed Authentication
  - Authorization Failures
  - Session Tracking Problems
  - Critical portions of business logic

Application Level Logging

- Application should log this information:
  - Server Identity
  - Client IP Address
  - Username
  - Date/Time
  - URL
  - POST data
  - Cookies

Logging Frameworks

- Logging frameworks provide an easy way for developers to implement and configure logging
- Common logging frameworks:
  - Log4j / Log4net / Log4PLSQL
  - Java's java.util.logging
  - The Object Guy's dotnetlog / javalog

Remediation

Remediation

- When web application analysis is exhausted, need to determine if a standard forensic analysis is warranted
- Need to determine a remediation plan:
  - Recover from current state
  - Restore from backup
  - Rebuild from scratch
- Ensure that causes of the incident are addressed

Conclusion

- Application forensics requires a concerted effort between system administrators, network administrators, security staff and developers
- Responders need to be intimately familiar with application security issues
- Enhance your forensics and incident response checklists
- There is no one right way!

Questions?

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