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# CS 305 Project One

**Artemis Financial Vulnerability Assessment Report**

Table of Contents

[Document Revision History 3](#_Toc32574607)

[Client 3](#_Toc32574608)

[Instructions 3](#_Toc32574609)

[Developer 4](#_Toc32574610)

[1. Interpreting Client Needs 4](#_Toc32574611)

[2. Areas of Security 4](#_Toc32574612)

[3. Manual Review 4](#_Toc32574613)

[4. Static Testing 4](#_Toc32574614)

[5. Mitigation Plan 4](#_Toc32574615)

## Document Revision History

| **Version** | **Date** | **Author** | **Comments** |
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| **1.0** | **9/18/2021** | **Charles Ballard** | **Initial Assessment** |

## Client



## Instructions

Deliver this completed vulnerability assessment report, identifying your findings of security vulnerabilities and articulating recommendations for next steps to remedy the issues you have found.

Respond to the five steps outlined below and include your findings. Replace the bracketed text on all pages with your own words. If you choose to include images or supporting materials, be sure to insert them throughout.

## Developer

Charles Ballard

## 1. Interpreting Client Needs

Determine your client’s needs and potential threats and attacks associated with their application and software security requirements. Consider the following regarding how companies protect against external threats based on the scenario information:

* What is the value of secure communications to the company?
* Are there any international transactions that the company produces?
* Are there governmental restrictions about secure communications to consider?
* What external threats might be present now and in the immediate future?
* What are the “modernization” requirements that must be considered, such as the role of open source libraries and evolving web application technologies?

Given the nature of the data being handled by Artemis Financial via their web application (Personally Identifiable Information (PII), Heath Insurance Portability and Accountability Act (HIPAA) information, and financial data), it is essential that all communications coming to and leaving from the application are secured. While not explicitly stated, it is not unreasonable that this data may originate from or designate to international customers and locations. Therefore, the application should conform to GDPR standards for consumer privacy protection. Based on the data handled by the application, it is also reasonable to assume that this data will be under constant threat from attackers looking to procure consumers personal information to use for monetary gain. This application will be subject to SQL injection, JSON injection, DoS, and man-in-the-middle attacks among potentially others. Because of the high-value nature of the data being handled, the application should undergo constant security reviews to ensure that only the most up-to-date and stable architecture is in production at all times.

## 2. Areas of Security

Referring to the Vulnerability Assessment Process Flow Diagram, identify which areas of security are applicable to Artemis Financial’s software application. Justify your reasoning for why each area is relevant to the software application.

Input Validation – The application is taking input from users and will need to provide some type of validation that the input is not malicious and fits the requirements of the API prior to being passed through the API call.

APIs – The RESTful API must utilize the proper request handling methods to prevent exposing information about the underlying application architecture.

Cryptography – The application will manage PII, HIPPA, and financial information and must provide secure encryption to prevent the information leaking.

Client/Server – The application will connect to a secure SQL DB server and must provide appropriate Authentication and Authorization methods to preserve the principle of least privilege.

Code Error – Application errors must be handled privately and stored away from external access to prevent exposing underlying application architecture.

Encapsulation – Proper data structures must be implemented to prevent unwanted class manipulation.

## 3. Manual Review

Continue working through the Vulnerability Assessment Process Flow Diagram. Identify all vulnerabilities in the code base by manually inspecting the code.

Injection Vulnerability - CRUDController.java – Line 13 – Lack of input validation and parameterization of incoming user-supplied data.

Authentication & Authorization Vulnerability – customer.java – No Auth&Auth solution implemented allowing for uncontrolled access to account information

Persistent Session Vulnerability – customer.java – Line 7 – Lack of a coded timeout for display session to protect customer data on the client side

Authentication & Authorization Vulnerability – DocData.java – Line 28 – try method provides for a database connection without access authentication or query authorization at the session level. Credentials provided present the opportunity for root access to the database.

Architectural Exposure Vulnerability – DocData.java – Line 31 – Simply printing the stack trace could allow for malicious actors to gain inside knowledge of architectural implementations that could lead to additional penetration attempts.

Injection Vulnerability - GreetingController.java – Line 17 – Lack of input validation and parameterization of incoming user-supplied data.

Class Mutability Vulnerability – myDateTime.java – mutable class implementation allows for potential malicious code injection

DoS Vulnerability – application.properties – Line 7 – max-file-size is set to 200MB allowing for very large file uploads beyond the scope of the application handling

DoS Vulnerability – application.properties – Line 9 – max-request-size is set to 215MB allowing for very large requests beyond the scope of the application handling

## 4. Static Testing

Run a dependency check on Artemis Financial’s software application to identify all security vulnerabilities in the code. Record the output from dependency check report. Include the following:

1. The names or vulnerability codes of the known vulnerabilities
2. A brief description and recommended solutions provided by the dependency check report
3. Attribution (if any) that documents how this vulnerability has been identified or documented previously

CVE-2013-1624

The TLS implementation in the Bouncy Castle Java library before 1.48 and C# library before 1.8 does not properly consider timing side-channel attacks on a noncompliant MAC check operation during the processing of malformed CBC padding, which allows remote attackers to conduct distinguishing attacks and plaintext-recovery attacks via statistical analysis of timing data for crafted packets, a related issue to CVE-2013-0169.

CVE-2015-6644

An information disclosure vulnerability in Bouncy Castle could enable a local malicious application to gain access to user’s private information

CVE-2015-7940

The Bouncy Castle Java library before 1.51 does not validate a point is withing the elliptic curve, which makes it easier for remote attackers to obtain private keys via a series of crafted elliptic curve Diffie Hellman (ECDH) key exchanges, aka an "invalid curve attack."

CVE-2016-1000338

In Bouncy Castle JCE Provider version 1.55 and earlier the DSA does not fully validate ASN.1 encoding of signature on verification. It is possible to inject extra elements in the sequence making up the signature and still have it validate, which in some cases may allow the introduction of 'invisible' data into a signed structure.

CVE-2016-1000339

In the Bouncy Castle JCE Provider version 1.55 and earlier the primary engine class used for AES was AESFastEngine. Due to the highly table-driven approach used in the algorithm it turns out that if the data channel on the CPU can be monitored the lookup table accesses are sufficient to leak information on the AES key being used. There was also a leak in AESEngine although it was substantially less. AESEngine has been modified to remove any signs of leakage (testing carried out on Intel X86-64) and is now the primary AES class for the BC JCE provider from 1.56. Use of AESFastEngine is now only recommended where otherwise deemed appropriate.

CVE-2016-1000341

In the Bouncy Castle JCE Provider version 1.55 and earlier DSA signature generation is vulnerable to timing attack. Where timings can be closely observed for the generation of signatures, the lack of blinding in 1.55, or earlier, may allow an attacker to gain information about the signature's k value and ultimately the private value as well.

CVE-2016-1000342

In the Bouncy Castle JCE Provider version 1.55 and earlier ECDSA does not fully validate ASN.1 encoding of signature on verification. It is possible to inject extra elements in the sequence making up the signature and still have it validate, which in some cases may allow the introduction of 'invisible' data into a signed structure.

CVE-2016-1000343

In the Bouncy Castle JCE Provider version 1.55 and earlier the DSA key pair generator generates a weak private key if used with default values. If the JCA key pair generator is not explicitly initialized with DSA parameters, 1.55 and earlier generates a private value assuming a 1024 bit key size. In earlier releases this can be dealt with by explicitly passing parameters to the key pair generator.

CVE-2016-1000344

In the Bouncy Castle JCE Provider version 1.55 and earlier the DHIES implementation allowed the use of ECB mode. This mode is regarded as unsafe and support for it has been removed from the provider.

CVE-2016-1000345

In the Bouncy Castle JCE Provider version 1.55 and earlier the DHIES/ECIES CBC mode vulnerable to padding oracle attack. For BC 1.55 and older, in an environment where timings can be easily observed, it is possible with enough observations to identify when the decryption is failing due to padding.

CVE-2016-1000346

In the Bouncy Castle JCE Provider version 1.55 and earlier the other party DH public key is not fully validated. This can cause issues as invalid keys can be used to reveal details about the other party's private key where static Diffie-Hellman is in use. As of release 1.56 the key parameters are checked on agreement calculation.

CVE-2016-1000352

In the Bouncy Castle JCE Provider version 1.55 and earlier the ECIES implementation allowed the use of ECB mode. This mode is regarded as unsafe and support for it has been removed from the provider.

CVE-2017-13098

BouncyCastle TLS prior to version 1.0.3, when configured to use the JCE (Java Cryptography Extension) for cryptographic functions, provides a weak Bleichenbacher oracle when any TLS cipher suite using RSA key exchange is negotiated. An attacker can recover the private key from a vulnerable application. This vulnerability is referred to as "ROBOT."

CVE-2018-1000613

Legion of the Bouncy Castle Legion of the Bouncy Castle Java Cryptography APIs 1.58 up to but not including 1.60 contains a CWE-470: Use of Externally Controlled Input to Select Classes or Code ('Unsafe Reflection') vulnerability in XMSS/XMSS^MT private key deserialization that can result in Deserializing an XMSS/XMSS^MT private key can result in the execution of unexpected code. This attack appears to be exploitable via A handcrafted private key can include references to unexpected classes which will be picked up from the class path for the executing application. This vulnerability appears to have been fixed in 1.60 and later.

CVE-2018-5382

The default BKS keystore use an HMAC that is only 16 bits long, which can allow an attacker to compromise the integrity of a BKS keystore. Bouncy Castle release 1.47 changes the BKS format to a format which uses a 160 bit HMAC instead. This applies to any BKS keystore generated prior to BC 1.47. For situations where people need to create the files for legacy reasons a specific keystore type "BKS-V1" was introduced in 1.49. It should be noted that the use of "BKS-V1" is discouraged by the library authors and should only be used where it is otherwise safe to do so, as in where the use of a 16 bit checksum for the file integrity check is not going to cause a security issue in itself.

CVE-2020-15522

Bouncy Castle BC Java before 1.66, BC C# .NET before 1.8.7, BC-FJA before 1.0.1.2, 1.0.2.1, and BC-FNA before 1.0.1.1 have a timing issue within the EC math library that can expose information about the private key when an attacker is able to observe timing information for the generation of multiple deterministic ECDSA signatures.

CVE-2020-26939

In Legion of the Bouncy Castle BC before 1.61 and BC-FJA before 1.0.1.2, attackers can obtain sensitive information about a private exponent because of Observable Differences in Behavior to Error Inputs. This occurs in org.bouncycastle.crypto.encodings.OAEPEncoding. Sending invalid ciphertext that decrypts to a short payload in the OAEP Decoder could result in the throwing of an early exception, potentially leaking some information about the private exponent of the RSA private key performing the encryption.

CVE-2020-10693

A flaw was found in Hibernate Validator version 6.1.2.Final. A bug in the message interpolation processor enables invalid EL expressions to be evaluated as if they were valid. This flaw allows attackers to bypass input sanitation (escaping, stripping) controls that developers may have put in place when handling user-controlled data in error messages.

CVE-2020-25649

A flaw was found in FasterXML Jackson Databind, where it did not have entity expansion secured properly. This flaw allows vulnerability to XML external entity (XXE) attacks. The highest threat from this vulnerability is data integrity.

CVE-2020-9488

Improper validation of certificate with host mismatch in Apache Log4j SMTP appender. This could allow an SMTPS connection to be intercepted by a man-in-the-middle attack which could leak any log messages sent through that appender.

CVE-2017-18640

The Alias feature in SnakeYAML 1.18 allows entity expansion during a load operation, a related issue to CVE-2003-1564

CVE-2020-5421

In Spring Framework versions 5.2.0 - 5.2.8, 5.1.0 - 5.1.17, 5.0.0 - 5.0.18, 4.3.0 - 4.3.28, and older unsupported versions, the protections against RFD attacks from CVE-2015-5211 may be bypassed depending on the browser used through the use of a jsessionid path parameter.

NVD-CWE-noinfo

CVE-2021-22118

In Spring Framework, versions 5.2.x prior to 5.2.15 and versions 5.3.x prior to 5.3.7, a WebFlux application is vulnerable to a privilege escalation: by (re)creating the temporary storage directory, a locally authenticated malicious user can read or modify files that have been uploaded to the WebFlux application or overwrite arbitrary files with multipart request data.

CVE-2019-17569

The refactoring present in Apache Tomcat 9.0.28 to 9.0.30, 8.5.48 to 8.5.50 and 7.0.98 to 7.0.99 introduced a regression. The result of the regression was that invalid Transfer-Encoding headers were incorrectly processed leading to a possibility of HTTP Request Smuggling if Tomcat was located behind a reverse proxy that incorrectly handled the invalid Transfer-Encoding header in a particular manner. Such a reverse proxy is considered unlikely.

CVE-2020-11996

A specially crafted sequence of HTTP/2 requests sent to Apache Tomcat 10.0.0-M1 to 10.0.0-M5, 9.0.0.M1 to 9.0.35 and 8.5.0 to 8.5.55 could trigger high CPU usage for several seconds. If a sufficient number of such requests were made on concurrent HTTP/2 connections, the server could become unresponsive.

CVE-2020-13934

An h2c direct connection to Apache Tomcat 10.0.0-M1 to 10.0.0-M6, 9.0.0.M5 to 9.0.36 and 8.5.1 to 8.5.56 did not release the HTTP/1.1 processor after the upgrade to HTTP/2. If a sufficient number of such requests were made, an OutOfMemoryException could occur leading to a denial of service.

CVE-2020-13935

The payload length in a WebSocket frame was not correctly validated in Apache Tomcat 10.0.0-M1 to 10.0.0-M6, 9.0.0.M1 to 9.0.36, 8.5.0 to 8.5.56 and 7.0.27 to 7.0.104. Invalid payload lengths could trigger an infinite loop. Multiple requests with invalid payload lengths could lead to a denial of service.

CVE-2020-13943

If an HTTP/2 client connecting to Apache Tomcat 10.0.0-M1 to 10.0.0-M7, 9.0.0.M1 to 9.0.37 or 8.5.0 to 8.5.57 exceeded the agreed maximum number of concurrent streams for a connection (in violation of the HTTP/2 protocol), it was possible that a subsequent request made on that connection could contain HTTP headers - including HTTP/2 pseudo headers - from a previous request rather than the intended headers. This could lead to users seeing responses for unexpected resources.

CVE-2020-17527

While investigating bug 64830 it was discovered that Apache Tomcat 10.0.0-M1 to 10.0.0-M9, 9.0.0-M1 to 9.0.39 and 8.5.0 to 8.5.59 could re-use an HTTP request header value from the previous stream received on an HTTP/2 connection for the request associated with the subsequent stream. While this would most likely lead to an error and the closure of the HTTP/2 connection, it is possible that information could leak between requests.

CVE-2020-1935

In Apache Tomcat 9.0.0.M1 to 9.0.30, 8.5.0 to 8.5.50 and 7.0.0 to 7.0.99 the HTTP header parsing code used an approach to end-of-line parsing that allowed some invalid HTTP headers to be parsed as valid. This led to a possibility of HTTP Request Smuggling if Tomcat was located behind a reverse proxy that incorrectly handled the invalid Transfer-Encoding header in a particular manner. Such a reverse proxy is considered unlikely.

CVE-2020-1938

When using the Apache JServ Protocol (AJP), care must be taken when trusting incoming connections to Apache Tomcat. Tomcat treats AJP connections as having higher trust than, for example, a similar HTTP connection. If such connections are available to an attacker, they can be exploited in ways that may be surprising. In Apache Tomcat 9.0.0.M1 to 9.0.0.30, 8.5.0 to 8.5.50 and 7.0.0 to 7.0.99, Tomcat shipped with an AJP Connector enabled by default that listened on all configured IP addresses. It was expected (and recommended in the security guide) that this Connector would be disabled if not required. This vulnerability report identified a mechanism that allowed: - returning arbitrary files from anywhere in the web application - processing any file in the web application as a JSP Further, if the web application allowed file upload and stored those files within the web application (or the attacker was able to control the content of the web application by some other means) then this, along with the ability to process a file as a JSP, made remote code execution possible. It is important to note that mitigation is only required if an AJP port is accessible to untrusted users. Users wishing to take a defense-in-depth approach and block the vector that permits returning arbitrary files and execution as JSP may upgrade to Apache Tomcat 9.0.31, 8.5.51 or 7.0.100 or later. A number of changes were made to the default AJP Connector configuration in 9.0.31 to harden the default configuration. It is likely that users upgrading to 9.0.31, 8.5.51 or 7.0.100 or later will need to make small changes to their configurations.

CVE-2020-9484

When using Apache Tomcat versions 10.0.0-M1 to 10.0.0-M4, 9.0.0.M1 to 9.0.34, 8.5.0 to 8.5.54 and 7.0.0 to 7.0.103 if a) an attacker is able to control the contents and name of a file on the server; and b) the server is configured to use the PersistenceManager with a FileStore; and c) the PersistenceManager is configured with sessionAttributeValueClassNameFilter="null" (the default unless a SecurityManager is used) or a sufficiently lax filter to allow the attacker provided object to be deserialized; and d) the attacker knows the relative file path from the storage location used by FileStore to the file the attacker has control over; then, using a specifically crafted request, the attacker will be able to trigger remote code execution via deserialization of the file under their control. Note that all of conditions a) to d) must be true for the attack to succeed.

CVE-2021-24122

When serving resources from a network location using the NTFS file system, Apache Tomcat versions 10.0.0-M1 to 10.0.0-M9, 9.0.0.M1 to 9.0.39, 8.5.0 to 8.5.59 and 7.0.0 to 7.0.106 were susceptible to JSP source code disclosure in some configurations. The root cause was the unexpected behaviour of the JRE API File.getCanonicalPath() which in turn was caused by the inconsistent behaviour of the Windows API (FindFirstFileW) in some circumstances.

CVE-2021-25122

When responding to new h2c connection requests, Apache Tomcat versions 10.0.0-M1 to 10.0.0, 9.0.0.M1 to 9.0.41 and 8.5.0 to 8.5.61 could duplicate request headers and a limited amount of request body from one request to another meaning user A and user B could both see the results of user A's request.

CVE-2021-25329

The fix for CVE-2020-9484 was incomplete. When using Apache Tomcat 10.0.0-M1 to 10.0.0, 9.0.0.M1 to 9.0.41, 8.5.0 to 8.5.61 or 7.0.0. to 7.0.107 with a configuration edge case that was highly unlikely to be used, the Tomcat instance was still vulnerable to CVE-2020-9494. Note that both the previously published prerequisites for CVE-2020-9484 and the previously published mitigations for CVE-2020-9484 also apply to this issue.

CVE-2021-30640

A vulnerability in the JNDI Realm of Apache Tomcat allows an attacker to authenticate using variations of a valid username and/or to bypass some of the protection provided by the LockOut Realm. This issue affects Apache Tomcat 10.0.0-M1 to 10.0.5; 9.0.0.M1 to 9.0.45; 8.5.0 to 8.5.65.

CVE-2021-33037

Apache Tomcat 10.0.0-M1 to 10.0.6, 9.0.0.M1 to 9.0.46 and 8.5.0 to 8.5.66 did not correctly parse the HTTP transfer-encoding request header in some circumstances leading to the possibility to request smuggling when used with a reverse proxy. Specifically: - Tomcat incorrectly ignored the transfer encoding header if the client declared it would only accept an HTTP/1.0 response; - Tomcat honored the identify encoding; and - Tomcat did not ensure that, if present, the chunked encoding was the final encoding.

CVE-2020-11996

A specially crafted sequence of HTTP/2 requests sent to Apache Tomcat 10.0.0-M1 to 10.0.0-M5, 9.0.0.M1 to 9.0.35 and 8.5.0 to 8.5.55 could trigger high CPU usage for several seconds. If a sufficient number of such requests were made on concurrent HTTP/2 connections, the server could become unresponsive.

CVE-2020-8022

An Incorrect Default Permissions vulnerability in the packaging of tomcat on SUSE Enterprise Storage 5, SUSE Linux Enterprise Server 12-SP2-BCL, SUSE Linux Enterprise Server 12-SP2-LTSS, SUSE Linux Enterprise Server 12-SP3-BCL, SUSE Linux Enterprise Server 12-SP3-LTSS, SUSE Linux Enterprise Server 12-SP4, SUSE Linux Enterprise Server 12-SP5, SUSE Linux Enterprise Server 15-LTSS, SUSE Linux Enterprise Server for SAP 12-SP2, SUSE Linux Enterprise Server for SAP 12-SP3, SUSE Linux Enterprise Server for SAP 15, SUSE OpenStack Cloud 7, SUSE OpenStack Cloud 8, SUSE OpenStack Cloud Crowbar 8 allows local attackers to escalate from group tomcat to root. This issue affects: SUSE Enterprise Storage 5 tomcat versions prior to 8.0.53-29.32.1. SUSE Linux Enterprise Server 12-SP2-BCL tomcat versions prior to 8.0.53-29.32.1. SUSE Linux Enterprise Server 12-SP2-LTSS tomcat versions prior to 8.0.53-29.32.1. SUSE Linux Enterprise Server 12-SP3-BCL tomcat versions prior to 8.0.53-29.32.1. SUSE Linux Enterprise Server 12-SP3-LTSS tomcat versions prior to 8.0.53-29.32.1. SUSE Linux Enterprise Server 12-SP4 tomcat versions prior to 9.0.35-3.39.1. SUSE Linux Enterprise Server 12-SP5 tomcat versions prior to 9.0.35-3.39.1. SUSE Linux Enterprise Server 15-LTSS tomcat versions prior to 9.0.35-3.57.3. SUSE Linux Enterprise Server for SAP 12-SP2 tomcat versions prior to 8.0.53-29.32.1. SUSE Linux Enterprise Server for SAP 12-SP3 tomcat versions prior to 8.0.53-29.32.1. SUSE Linux Enterprise Server for SAP 15 tomcat versions prior to 9.0.35-3.57.3. SUSE OpenStack Cloud 7 tomcat versions prior to 8.0.53-29.32.1. SUSE OpenStack Cloud 8 tomcat versions prior to 8.0.53-29.32.1. SUSE OpenStack Cloud Crowbar 8 tomcat versions prior to 8.0.53-29.32.1.

Graphical user interface, text, application, email

Description automatically generated

## 5. Mitigation Plan

After interpreting your results from the manual review and static testing, identify the steps to remedy the identified security vulnerabilities for Artemis Financial’s software application.

Each of the vulnerabilities listed in the Static Dependency check can be resolved by updating to the most recent versions of the respective dependencies.

Injection Vulnerability - CRUDController.java – Line 13 – Lack of input validation and parameterization of incoming user-supplied data. RESOLUTION: Store data passed in for the key “business\_name” as a variable prior to running data validation tests on the variable. Only a variable containing valid data should result in a successful constructor call for DocData.

Authentication & Authorization Vulnerability – customer.java – No Auth&Auth solution implemented allowing for uncontrolled access to account information. RESOLUTION: Implement OAuth session authentication and authorization for each API call.

Persistent Session Vulnerability – customer.java – Line 7 – Lack of a coded timeout for display session to protect customer data on the client side. RESOLUTION: Implement a timed session format for displaying sensitive user information through the browser. After a set time of inactivity, the browser should default to a time-out screen. The page displaying user information as well as the authenticated session to access the user information should not be cached by the browser or stored in the application.

Authentication & Authorization Vulnerability – DocData.java – Line 28 – try method provides for a database connection without access authentication or query authorization at the session level. Credentials provided present the opportunity for root access to the database. RESOLUTION: Implement OAuth session authentication and authorization for each API call. Remove hard coded username and password for the database and provide access and permissions to the DB through the OAuth layer.

Architectural Exposure Vulnerability – DocData.java – Line 31 – Simply printing the stack trace could allow for malicious actors to gain inside knowledge of architectural implementations that could lead to additional penetration attempts. RESOLUTION: Print the error log contents to a secure file system protected by administrator credentials on a secure server. Provide a custom error message to the user with a generic reason for DB connection failure.

Injection Vulnerability - GreetingController.java – Line 17 – Lack of input validation and parameterization of incoming user-supplied data. RESOLUTION: Store data passed in for the key “name” as a variable prior to running data validation tests on the variable. Only a variable containing valid data should result in a successful constructor call for Greeting.

Class Mutability Vulnerability – myDateTime.java – mutable class implementation allows for potential malicious code injection. RESOLUTION: Implement the date and time functionality via the java.time API as it is built to be inherently immutable.

DoS Vulnerability – application.properties – Line 7 – max-file-size is set to 200MB allowing for very large file uploads beyond the scope of the application handling. RESOLUTION: Reduce the maximum file size to limit denial of service through multiple large file uploads.

DoS Vulnerability – application.properties – Line 9 – max-request-size is set to 215MB allowing for very large requests beyond the scope of the application handling. RESOLUTION: Reduce the max-request-size to limit the amount of data that can be pulled from the API at any single instance.