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Analyzing Java heap dumps

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About

Defmax Technologies Pvt. Ltd. is an ISO 27001:2013 and 9001:2015 certified Information Security Company endeavouring organization's defence. We spot the vulnerabilities that an automated scanner can't detect, via manual penetration testing, our elite team is recognized as top-notch researchers around the globe and they provide quality reports on time under any precedence and we monitor our client's technologies 24/7 to ensure the risk mitigation of publicly disclosed vulnerabilities. The scope of the Security Assessment will include all components of each Information System namely: Application software, middleware, database, operating system and hardware and network infrastructure. The audit will also cover all interfaces to / from remote applications. Our team researchers work hard day and night to stay updated on security happenings and improve our client's assets by helping them transact, learn, and work securely.

Introduction

This research paper will shed light on analyzing Java heap dumps (hprof files) and searching for sensitive information using OQL (Object Query Language).

Key Terms

Heapdump, OQL, JWT

Definitions

1. **Heapdump**

   A heap dump is a snapshot of all the objects in the Java Virtual Machine (JVM) heap at a certain point in time. The JVM software allocates memory for objects from the heap for all class instances and arrays.

2. **OQL**

   Object Query Language (OQL) is a query language standard for object-oriented databases modeled after SQL and developed by the Object Data Management Group (ODMG). Because of its overall complexity the complete OQL standard has not yet been fully implemented in any software.

3. **JWT**

   JSON Web Token is a proposed Internet standard for creating data with optional signature and/or optional encryption whose payload holds JSON that asserts some number of claims. The tokens are signed either using a private secret or a public/private key.

Tools

1. Visual VM - https://visualvm.github.io/
2. Eclipse Memory Analyzer (MAT) - https://www.eclipse.org/mat/
3. Jwt_tool - https://github.com/ticarpi/jwt_tool

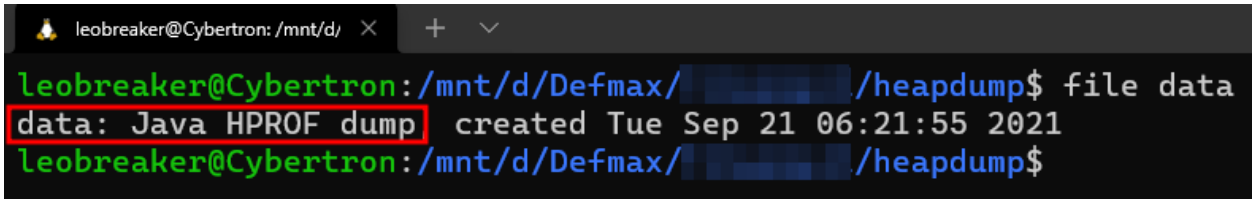
Analysis

During our pentest engagement we came across below mentioned endpoints which belonged to Spring Boot Actuator and were being exposed to the public.

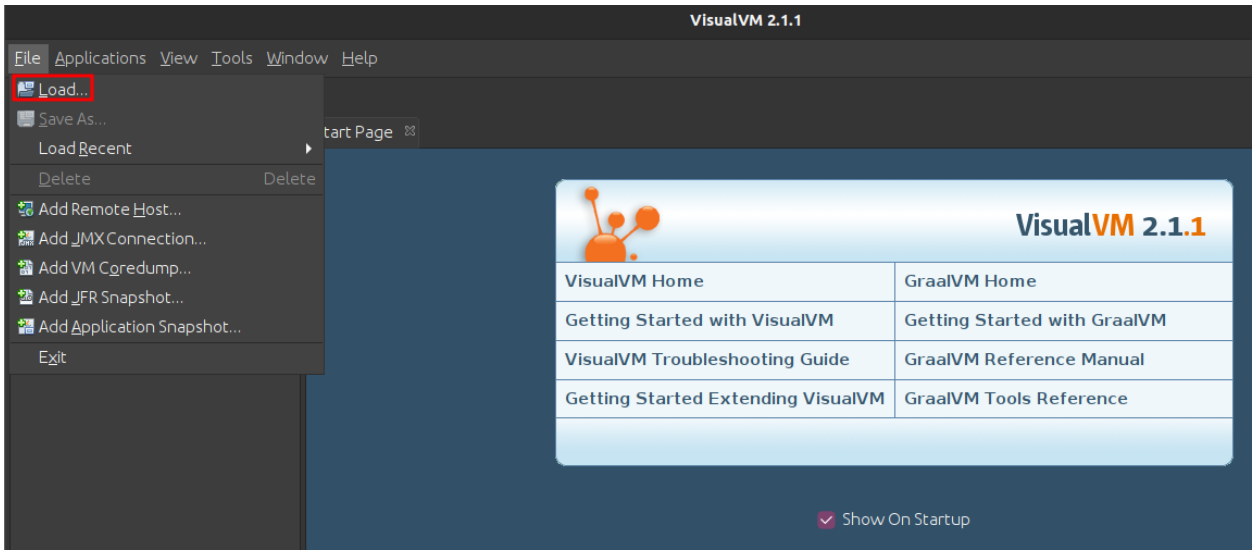
- /actuator/configprops
- /actuator/env
- /actuator/heapdump
- /actuator/loggers
- /actuator/metrics

We downloaded the head dump data and started analyzing it

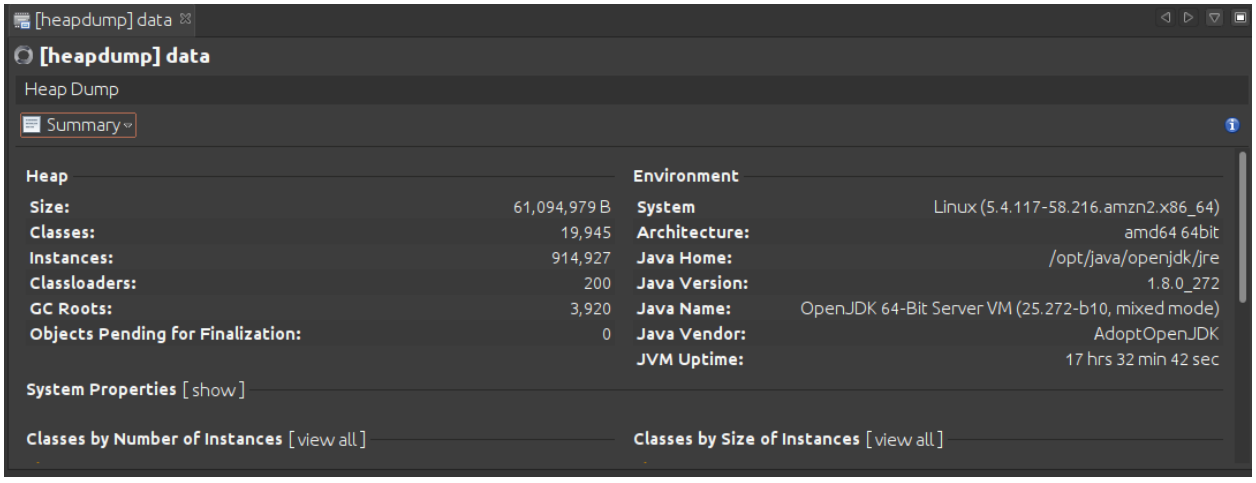
```
wget https://api.target.com/actuator/heapdump
```



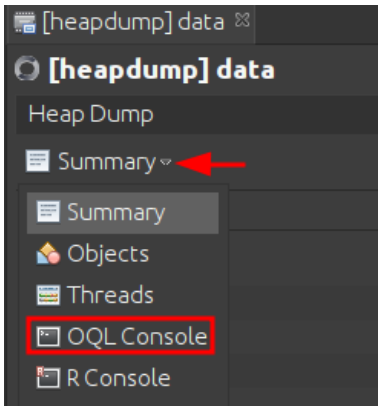
Open VisualVM and load the heap dump data



Once VisualVM has completed loading the file a detailed summary will be shown

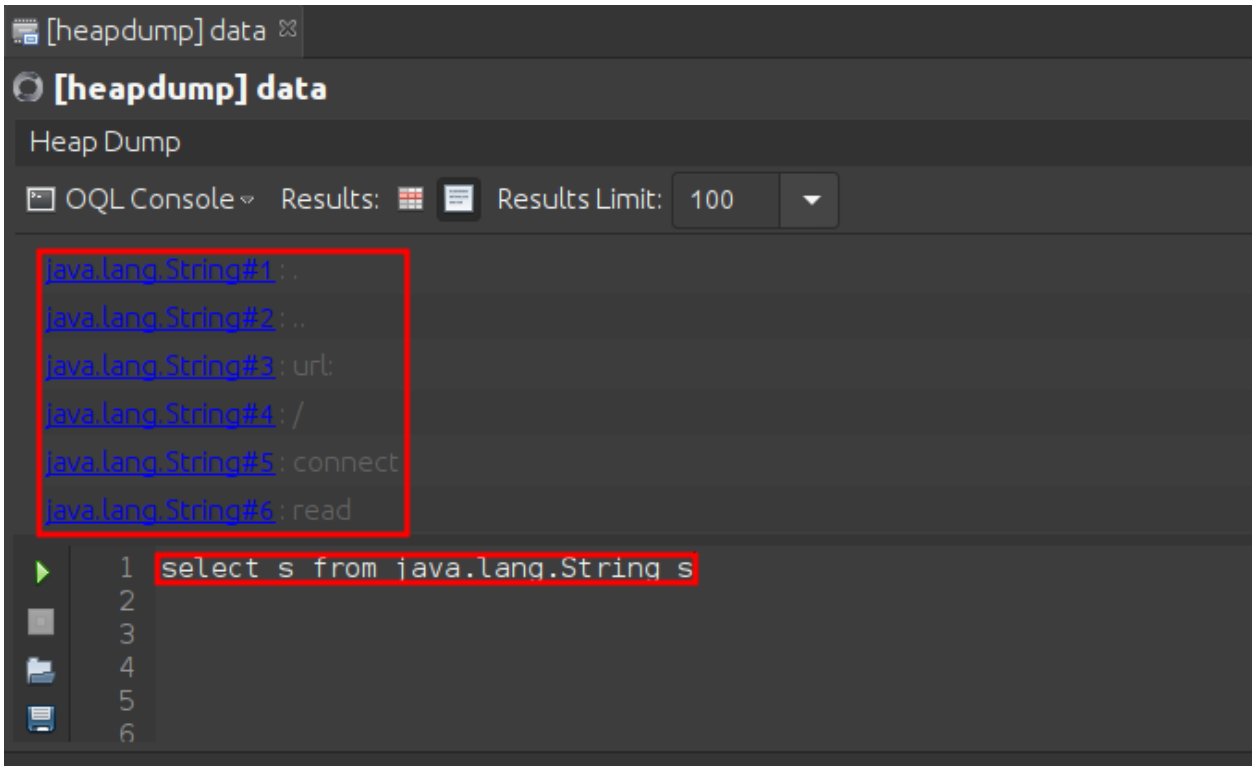


Switch to “OQL Console” from the menu



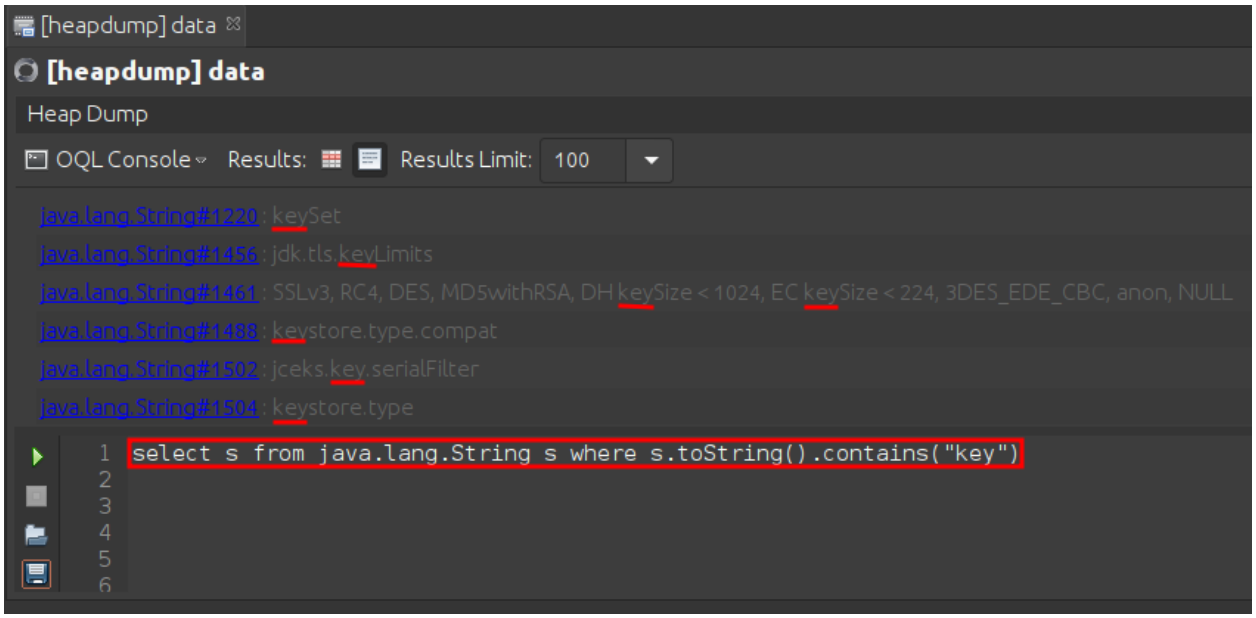
The below OQL query will display all the strings

```
select s from java.lang.String s
```



It’s impossible to go through all the results, let’s tweak our OQL query a bit to search for a specific keyword “key”

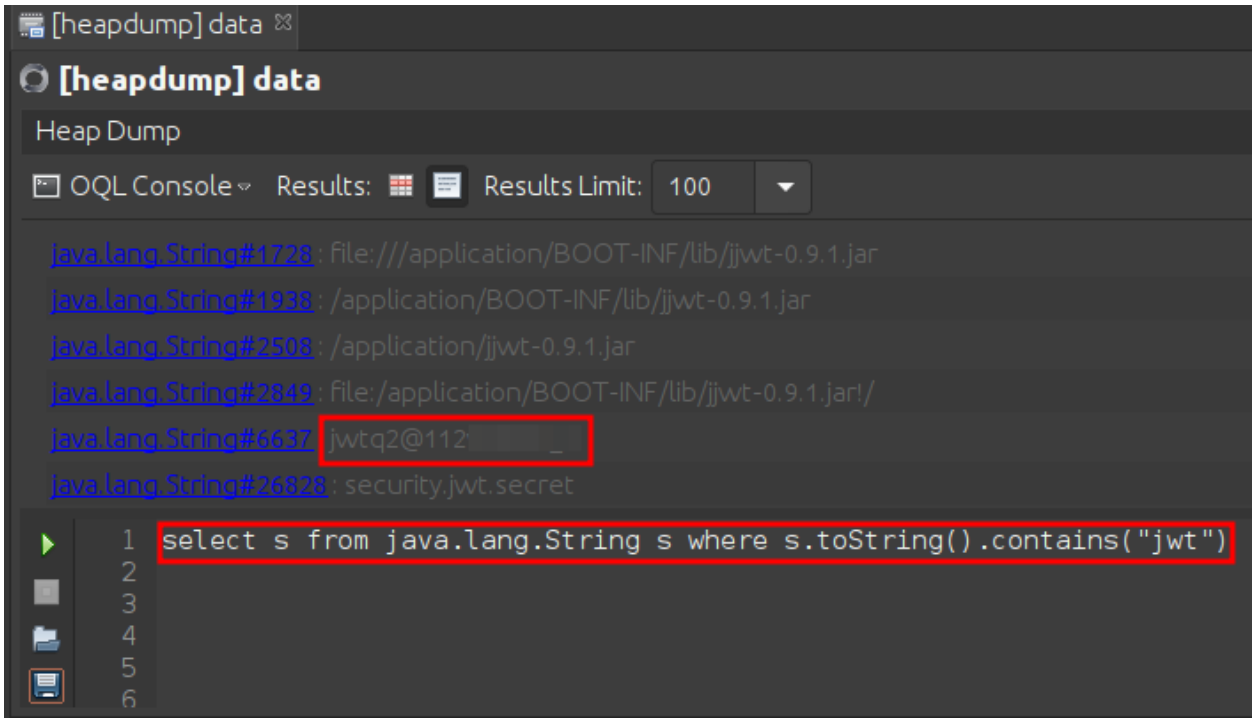
```
select s from java.lang.String s where
s.toString().contains("key")
```



Interesting, let's begin our search for sensitive information

Searching for the keyword "jwt" revealed an interesting string

```
select s from java.lang.String s where
s.toString().contains("jwt")
```

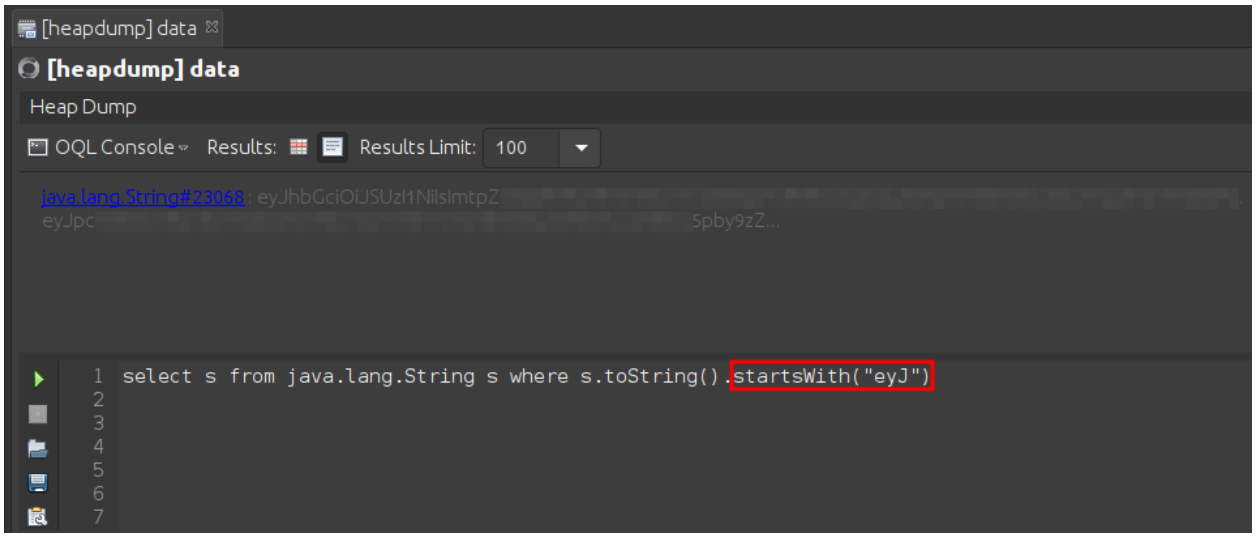


Let's confirm whether our guess is right, we checked the string found above with our own account's jwt token

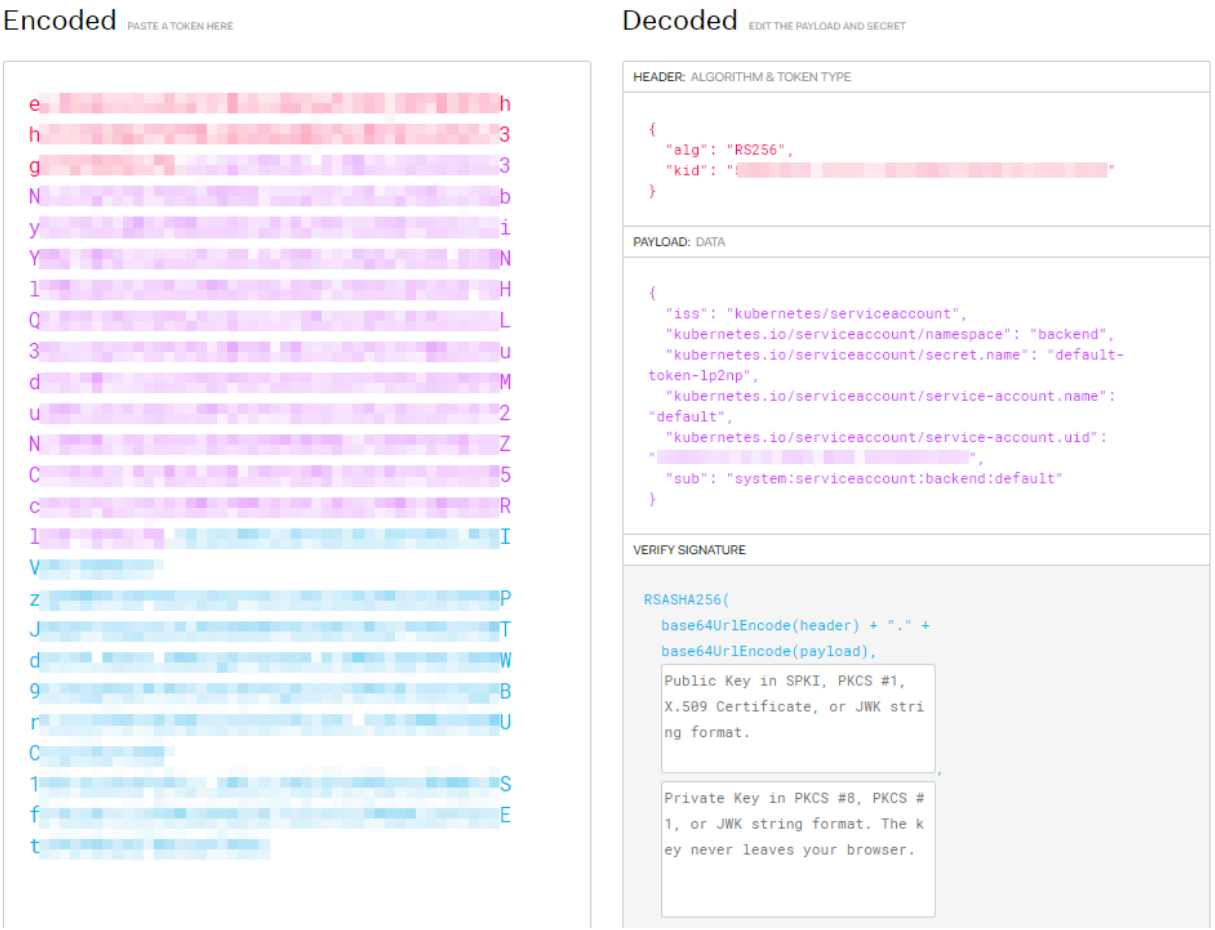
We found the JWT Secret Key! Let's keep digging

Let's try searching for strings that start with "eyJ" since this pattern was repeated in the JWT tokens

```
select s from java.lang.String s where
s.toString().startsWith("eyJ")
```



Looks like we found a JWT Token related to Kubernetes service account



Conclusion

Java heap dumps might contain sensitive information which shouldn't be exposed to the public.

References

- https://en.wikipedia.org/wiki/Object_Query_Language
- https://docs.oracle.com/javase/8/docs/technotes/guides/visualvm/heapdump.html
- https://jwt.io/