Fuzzing 101

NYU/Poly.edu

October 23, 2008

Mike Zusman

Hi, I'm Mike Zusman

Past:

- Web Application Developer
- Escalation Engineer @ Whale Communications, Inc (a Microsoft subsidiary)
- Application Security Team @ ADP, Inc
- Spoken at Industry Events: OWASP, BlackHat (and a cameo at DEFCON)

Current:

- Senior Consultant @ Intrepidus Group, Inc.

Great Expectations

- You already know how to fuzz ☺
- This class will teach you:
  - History of fuzzing
  - Fuzzing Methodologies
  - About Fuzzing tools you can use
- At the end of this class you:
  - Will have written your own fuzzer
  - Found some cool (hopefully exploitable) bugs

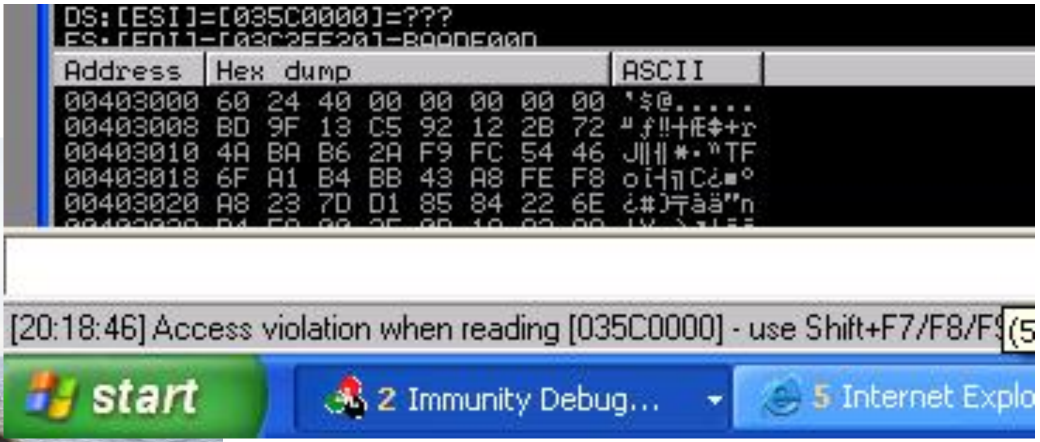
The Approach

- Fun entertaining lectures by me
- Lectures contain content from the "book" and my own experience.
- Homework

Michael Sutton
Adam Greene
Pedram Amini
Forward by HD Moore

The Spirit

- HAVE FUN!
  - When the weathers too bad, or my wife won’t let me go real “fishing”, I go fuzzing instead!



```
DS:[ESI]=[035C0000]=???
Address  Hex dump                 ASCII
00403000 60 24 40 00 00 00 00 00 '$@.....
00403008 BD 9F 13 C5 92 12 2B 72 ╜ƒ‼┼Æ↕+r
00403010 4A BA B6 2A F9 FC 54 46 J║╢*∙ⁿTF
00403018 6F A1 B4 BB 43 A8 FE F8 oí┤╗C¿■°
00403020 A8 23 7D D1 85 84 22 6E ¿#}╤àä"n
```

```
[20:18:46] Access violation when reading [035C0000] - use Shift+F7/F8/F9
```

What exactly is fuzzing?

"Fuzzing is the process of sending intentionally invalid data to a product in the hopes of triggering an error condition or fault. These error conditions can lead to exploitable vulnerabilities."

- HD Moore (from *Fuzzing*)

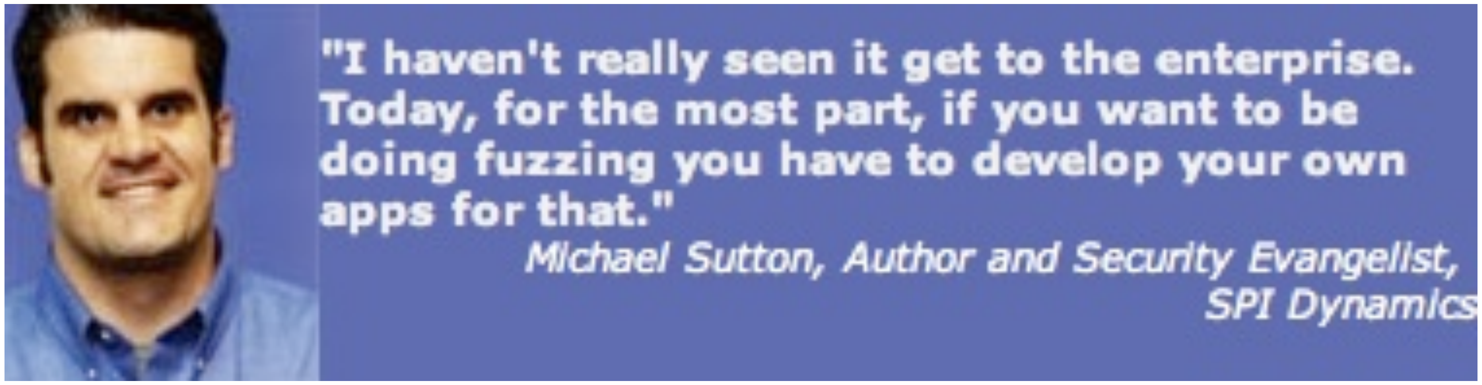
What exactly is fuzzing?

"Throw sh!t at the wall and see what sticks!" – b3nn

What exactly is fuzzing?

"There are no rules to fuzzing."

- *Fuzzing*, the book



"I haven't really seen it get to the enterprise. Today, for the most part, if you want to be doing fuzzing you have to develop your own apps for that."

Michael Sutton, Author and Security Evangelist, SPI Dynamics

"There are no guarantees in fuzzing."

- Me

History

- Fuzzing is not new
  - it’s been named for about 20 years.
- Professor Barton Miller
  - Father of Fuzzing
  - Developed fuzz testing with his students at the University of Wisconsin-Madison in 1988/89
  - GOAL: improve UNIX applications

History

- Millers fuzzer was pretty basic
- It sent random strings of data to the application
- If (CRASH||HANG) {Finding(fuzzStr);}
- Smarter fuzzers would follow…

History

- 1999 brought PROTOS from University of Oulu
- PROTOS began by analyzing PROTOcol specifications
- Packets were modeled that violated the specs
- Testing suites were designed that could be used against multiple vendor products

History

- 2002
  - Microsoft injects cash into PROTOS
- PROTOS members branch out and start Codenomicon
  - First Commercial Fuzzer

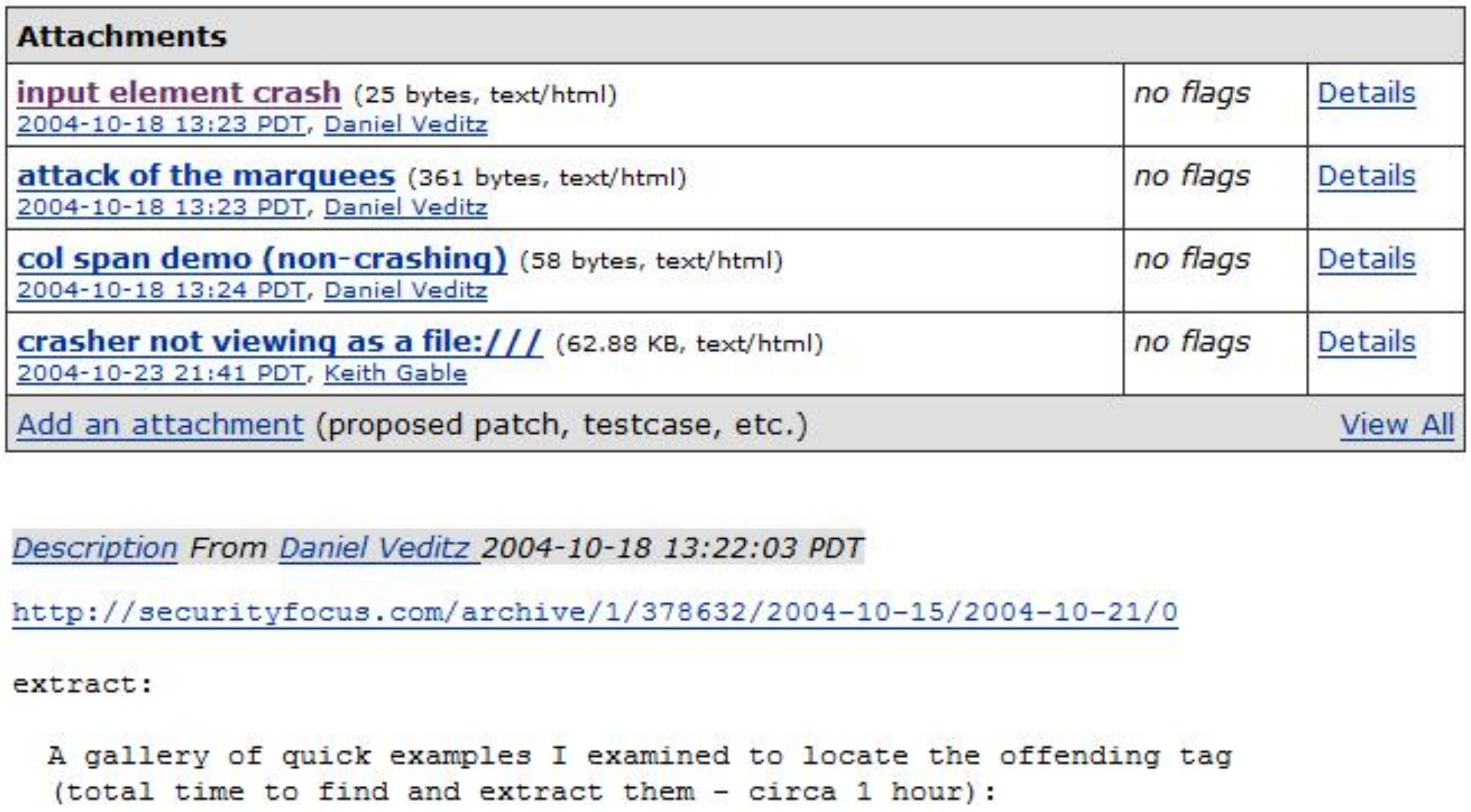
Today, Fuzzing is part of Microsoft's SDL Process!

History

- SPIKE fuzzer also released in 2002
  - Dave Aitel wrote it
- Where Millers fuzzer was dumb, SPIKE is a genius
  - Ability to describe data
  - Built in libraries for known protocols (*RPC)
  - Fuzz strings designed to make software fail

History

- 2004 Browser Fuzzing
- MangleMe – Michal Zalewski
  - Fuzzed HTML to find browser bugs



Attachments

input element crash (25 bytes, text/html) 2004-10-18 13:23 PDT, Daniel Veditz	*no flags*	Details
attack of the marquees (361 bytes, text/html) 2004-10-18 13:23 PDT, Daniel Veditz	*no flags*	Details
col span demo (non-crashing) (58 bytes, text/html) 2004-10-18 13:24 PDT, Daniel Veditz	*no flags*	Details
crasher not viewing as a file:/// (62.88 KB, text/html) 2004-10-23 21:41 PDT, Keith Gable	*no flags*	Details
Add an attachment (proposed patch, testcase, etc.)		View All

Description From Daniel Veditz 2004-10-18 13:22:03 PDT

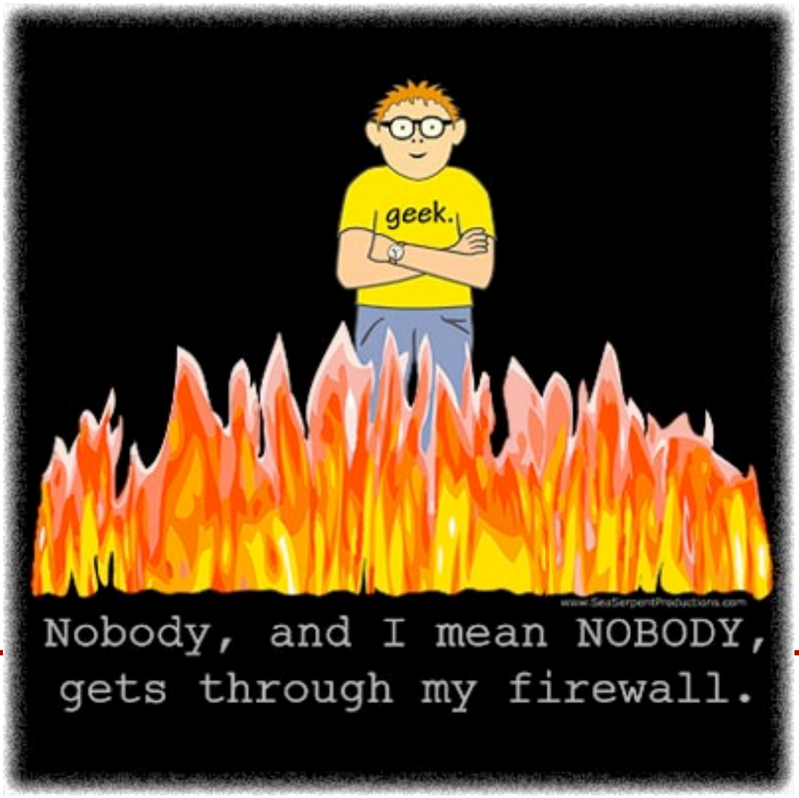
```
http://securityfocus.com/archive/1/378632/2004-10-15/2004-10-21/0

extract:

  A gallery of quick examples I examined to locate the offending tag
  (total time to find and extract them - circa 1 hour):
```

History

- 2004 File Format Fuzzing
- Microsoft Security Bulletin MS04-028
  - Buffer Overun in JPEG Processing (GDI+) Could Allow Remote Code Execution


geek.
www.SeaSerpentProductions.com
Nobody, and I mean NOBODY,
gets through my firewall.

History

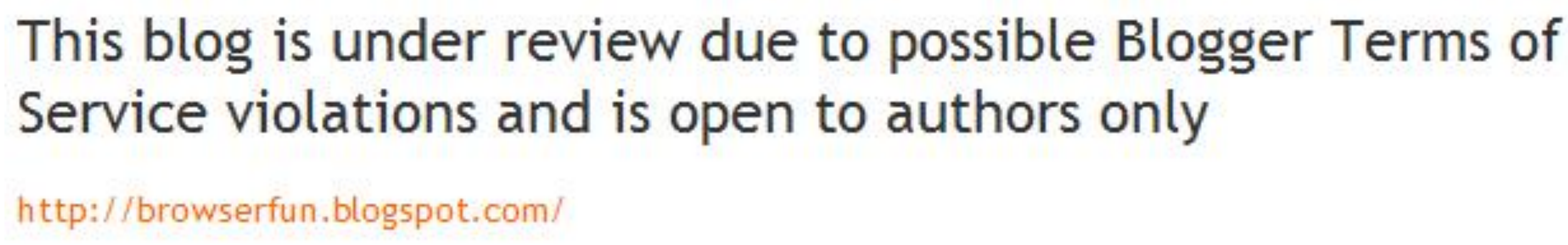
- 2005 File Format Fuzzers Released
- FileFuzz, SPIKEfile, notSPIKEfile
  - Michael Sutton and crew
- Then came the rain.
  - "When Office 2003 shipped, we thought we'd done some good work and that it would be a secure product," said David LeBlanc, a senior software development engineer with the Office team. "For the first two years after release, it held up really well, only two bulletins. [But] then people shifted their tactics and started finding problems in fairly large numbers." - http://www.infoworld.com/article/07/09/21/Microsoft-developer-Fuzzing-key-to-Office-security_1.html?DESKTOP%20SECURITY

History

- 2005 More Browser Fuzzers
- Hamachi
  - HD Moore, Aviv Raff
  - Fuzzed Dynamic HTML
- CSSDIE
  - HD Moore and crew
  - Fuzzed CSS Style Sheets

History

- 2006 Month of Browser Bugs
  - HD Moore and crew released a browser bug every day, with "no direct path to code execution." http://www.foxnews.com/story/0,2933,202547,00.html
  - Controversial?
    - Blogger thinks so


This blog is under review due to possible Blogger Terms of Service violations and is open to authors only

http://browserfun.blogspot.com/

History

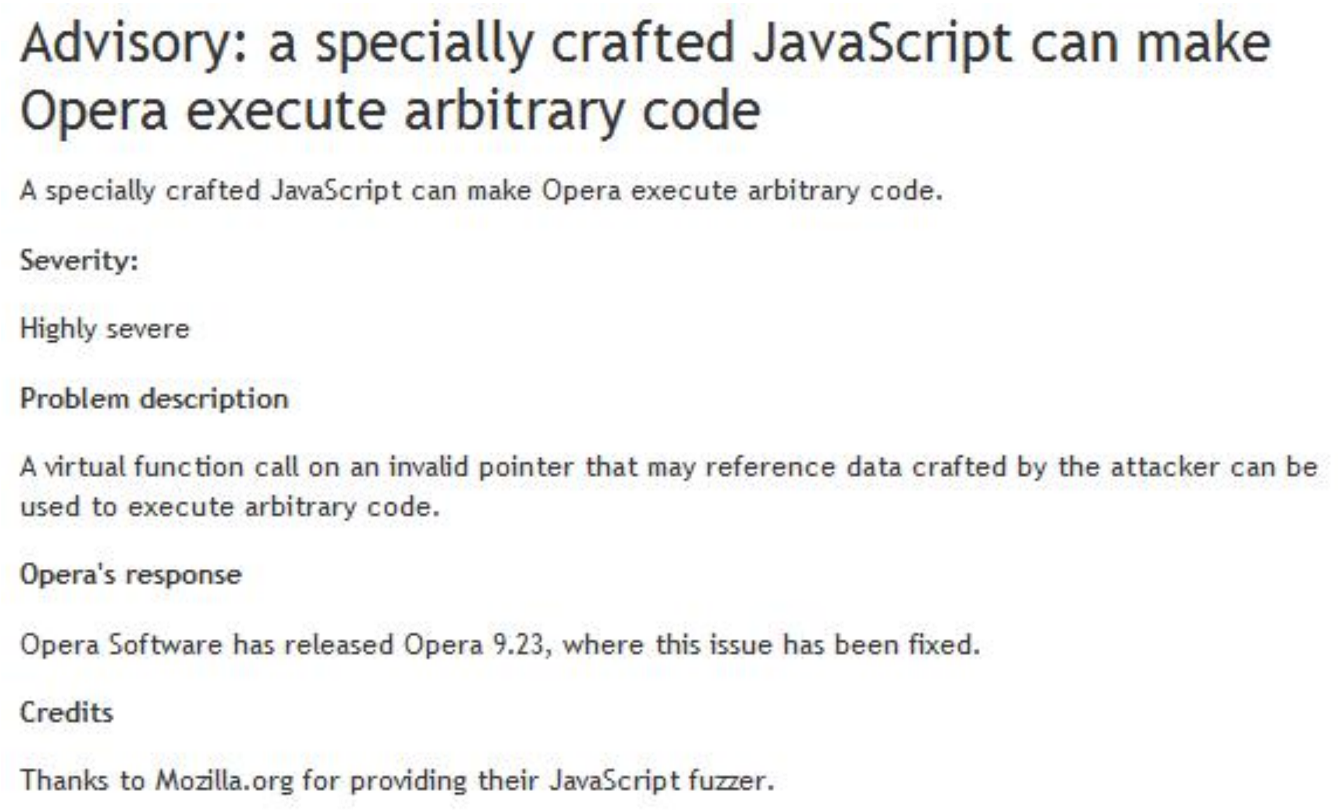
- 2006 ActiveX Fuzzing
  - When his car insurance went up, the GEICO caveman started selling ActiveX 0days (just kidding)
  - Too easy?

History

- 2006 ActiveX Fuzzing
- COMRaider
  - GUI Based
  - Point and Click
  - iDefense tool
- AxMan
  - More complicated to use then COMRaider
  - IMO, a better fuzzer
- Why so easy?
  - ActiveX/COM objects have exportable typelibs that describe all methods, interfaces, properties.

History

- 2007 More Browser Fuzzing



Advisory: a specially crafted JavaScript can make Opera execute arbitrary code

A specially crafted JavaScript can make Opera execute arbitrary code.

Severity:

Highly severe

Problem description

A virtual function call on an invalid pointer that may reference data crafted by the attacker can be used to execute arbitrary code.

Opera's response

Opera Software has released Opera 9.23, where this issue has been fixed.

Credits

Thanks to Mozilla.org for providing their JavaScript fuzzer.

History

- 2008
  - First time fuzzing is taught in a University setting? Maybe…

</history>

<fuzzers>

Fuzzing Methods

- Sending Random Data
  - Least Effective
  - Unfortunately, sometimes, code is bad enough for this to work
- Manual Protocol Mutation
  - You are the fuzzer
  - Time consuming, but can be accurate when you have a hunch
  - Web App Pen-Testing

Fuzzing Methods

- Mutation or Brute Force Testing
  - Starts with a valid sample
  - Fuzz each and every byte in the sample

- Automatic Protocol Generation Testing
  - Person needs to understand the protocol
  - Code is written to describe the protocol (a “grammar”)
  - Fuzzer then knows which piece to fuzz, and which to leave alone (SPIKE)

Types of Fuzzers

- Local Fuzzer
  - Lets you fuzz applications on the command line
  - To what end?
    - Make sure the target has some value (setuid)
- Environment Variable fuzzers
  - Because:

```
#include <string.h>
int main (int argc, char **argv)
{
        char buffer[10];
        strcpy(buffer, getenv("HOME"));
}
```

Types of Fuzzers

- File Format Fuzzers
  - Fuzz valid files
  - Pass them to an executable
- Remote Fuzzers (my favorite)
  - Listen on a network connects
  - When client connects, fuzz them!

Types of Fuzzers

- Network Protocol Fuzzers
  - The Fuzzer is the client
  - Need to understand the protocol
    - Simple Protocols
      - Text Based
      - Telnet, FTP, POP, HTTP
    - Complex Protocols
      - Binary Data (some ASCII)
      - Complex authentication, encryption, etc
      - MSRPC (Supported by SPIKE)

Types of Fuzzers

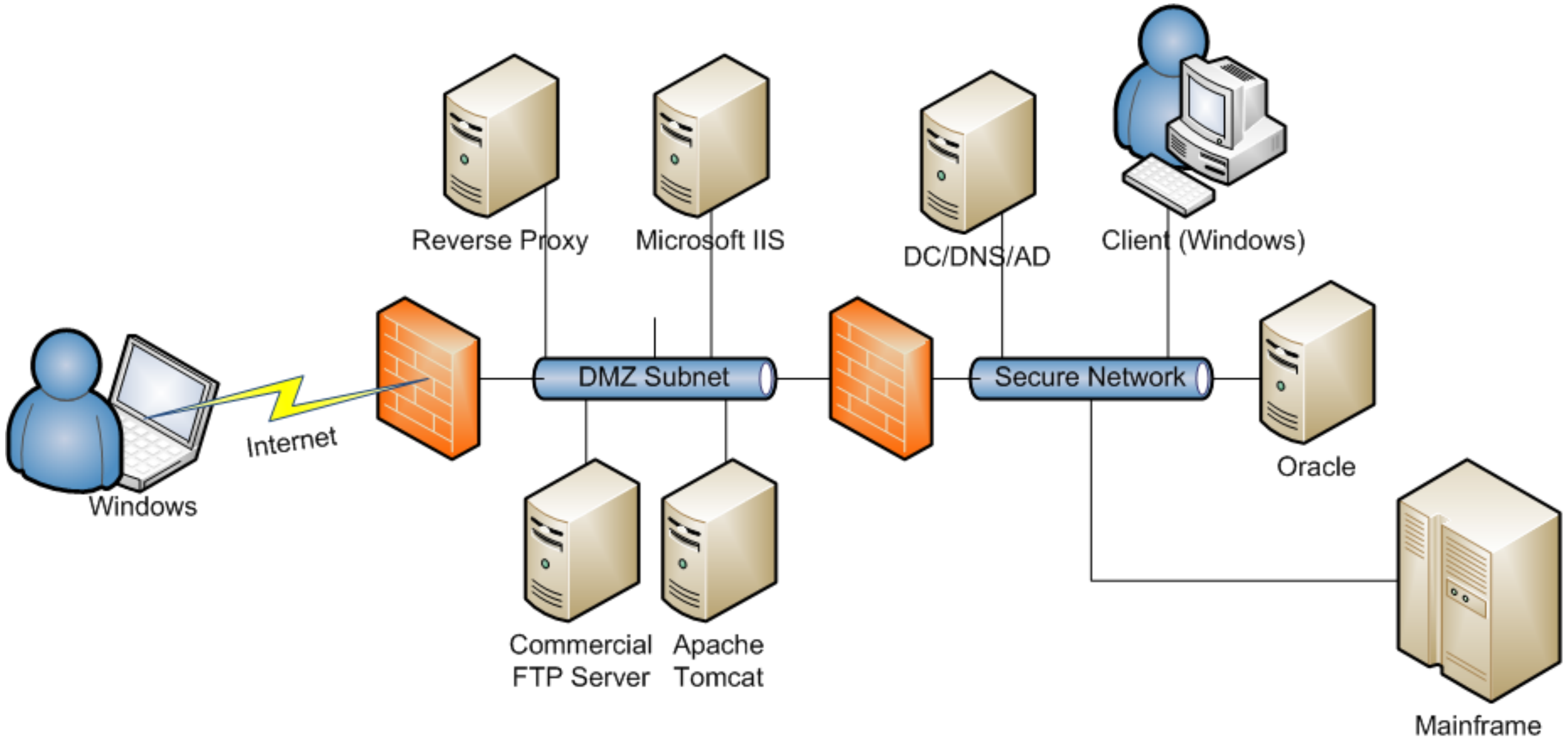
</fuzzers>

<fuzzing>

The Process of Fuzzing

1. **Identify Targets**
2. Identify Inputs
3. Generate Fuzzed Data
4. Execute Fuzzed Data
5. Monitor for Exceptions
6. Determine Exploitability

1. Identify Targets



The Process of Fuzzing

1. Target: Commercial FTP Server (WARFTP)
2. **Identify Inputs**
3. Generate Fuzzed Data
4. Execute Fuzzed Data
5. Monitor for Exceptions
6. Determine Exploitability

2. Identify Inputs

1. Target: Commercial FTP Server (WARFTP)
2. **Identify Inputs**

- TCP Port 21, p1, p2 (PASV or active?)
- Commands: USER, PASS, CWD, DELE, etc
- Special CHARs: \r\n, <space>

The Process of Fuzzing

1. Target: Commercial FTP Server (WARFTP)
2. Inputs: TCP21, Ftp Commands, Special Chars, binary files
3. **Generate Fuzzed Data**

USER <username>

Generation one: 1024 x A

Generation two: 2048 X A

Generation three: 4096 X String(random)

PASS <password>

Generation one: 1024 x A

Generation two: 2048 X A

The Process of Fuzzing

1. Target: Commercial FTP Server (WARFTP)
2. Inputs: TCP21, Ftp Commands, Special Chars, binary files
3. Fuzzed Data: <username>, <password>
4. **Execute Fuzzed Data**

```
for (int w=0; w<maxIterations; w++){
openhost();
for (int commandIndex = 0; commandIndex < commandCount; commandIndex++)
{
   userInput = commands[commandIndex].command;
   if (commands[commandIndex].argument.equals("%f")){
    //FUZZ IT
    if (AttackID != 4) {
      userInput = userInput + stringAttacks[w].replace("\r", "").replace("\n", "");
    } else {
      userInput = userInput + stringAttacks[w];
}
```

```
for (int w=0; w<maxIterations; w++){
openhost();
for (int commandIndex = 0; commandIndex < commandCount; commandIndex++)
{
   userInput = commands[commandIndex].command;
   if (commands[commandIndex].argument.equals("%f")){
    //FUZZ IT
    if (AttackID != 4) {
      userInput = userInput + stringAttacks[w].replace("\r", "").replace("\n", "");
    } else {
      userInput = userInput + stringAttacks[w];
   }
} else {
   userInput = userInput + " " + commands[commandIndex].argument;
}
userInput = userInput + "\r\n";
try {
   toServer.write(userInput.getBytes(),0,userInput.getBytes().length);
} catch (Exception e) {
  System.out.println("Connection dropped on write");
}
```

The Process of Fuzzing

1. Target: Commercial FTP Server (WARFTP)
2. Inputs: TCP21, Ftp Commands, Special Chars, binary files
3. Fuzzed Data: <username>, <password>
4. Send the Fuzzed Data to the Target (code)
5. **Monitor for Exceptions**

```
try {
   response = in.readLine();
if (!response.equals("")){
// do nothing
}
} catch (IOException e)
{
   System.out.println("ANOMALY: Connection was dropped.");
   if (AttackID != 4) System.out.println("ANOMALY: String length was " +
              stringAttacks[w].replace("\r", "").replace("\n", "").length());
}
catch (Exception e) …
```

The Process of Fuzzing

1. Target: Commercial FTP Server (WARFTP)
2. Inputs: TCP21, Ftp Commands, Special Chars, binary files
3. Fuzzed Data: <username>, <password>
4. Send the Fuzzed Data to the Target (code)
5. **Monitor for Exceptions**

```
try {
   response = in.readLine();
if (!response.equals("")){
// do nothing
}
} catch (IOException e)
{
   System.out.println("ANOMALY: Connection was dropped.");
   if (AttackID != 4) System.out.println("ANOMALY: String length was " +
            stringAttacks[w].replace("\r", "").replace("\n", "").length());
}
catch (Exception e) …
```

The Process of Fuzzing

1. Target: Commercial FTP Server (WARFTP)
2. Inputs: TCP21, Ftp Commands, Special Chars, binary files
3. Fuzzed Data: <username>, <password>
4. Send the Fuzzed Data to the Target (code)
5. Monitor the socket for any exceptions
6. **Determine Exploitability**

   Depends…

The Process of Fuzzing

- Determine Exploitability - Remotely
  - You need to know what data you sent
    - Record all fuzzed strings, making note of exceptions
    - Network Captures (Wireshark)
  - Try and reproduce the scenario
  - Is it a memory corruption bug?
  - Is it an application logic flaw?
- Determine Exploitability – Locally
  - Attach a debugger

Fuzzing Logistics

- "A good fuzzer needs to allow a user to quickly narrow down the iteration that caused the crash."
  - – stryde_hax

  - Log all fuzz attempts

  - The last one before an anomaly (exception) is the best place to start

Fuzzing Logistics

- Reproducibility Challenges
  - What if you are two days in on a fuzzing exercise, and you find a flaw.
  - How can you quickly reproduce the scenario that caused the crash?

<fuzzing_AX>

Fuzzing ActiveX Objects

- Target: Windows Workstations
- Inputs:
  Internet -> Internet Explorer -> ActiveX -> Interface -> Vulnerable Method/Property
- All fuzzing and fault detection is handled by COMRaider

- COMRaider Demo

Fuzzing ActiveX Objects

- Target: Windows Workstations
- Inputs:
  Internet -> Internet Explorer -> ActiveX -> Interface -> Vulnerable Method/Property
- Fuzzing is handled by AxMan, but not detection. We need an external debugger.
- AxMan Demo

Fuzzing ActiveX Objects

- Target: Windows Workstations
- Inputs:
  Internet -> Internet Explorer -> ActiveX -> Interface -> Vulnerable Method/Property
- Fuzzing is handled by AxMan, but not detection. We need an external debugger.
- AxMan Demo