PA193 - Secure coding principles and practices

Dynamic analysis, fuzzing

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Static and Dynamic analysis combined

- Download problematic code buggy.cpp from IS
- Perform operation and observe output
  - note tool name which found a particular bug
- Compilation only
  - Compile with MSVC /W4
  - Compile with g++ -Wall -Wextra -g
- Compile and run
  - **`MSVC /RTC /GS (on by default)`**
  - g++ **`-fstack-protector-all`**

Windows vs. Linux

- For Windows tools
  - use Visual Studio, cppcheck…
- For Linux tools
  - ssh aisa.fi.muni.cz
  - Compile with ‘g++ -g buggy.cpp’
- Run dynamic analysis (own computer or Aisa)

```
valgrind --tool=memcheck --leak-check=full ./yourprogram
valgrind --tool=exp-sgcheck ./yourprogram
```

Decide for every tool

- What type of issues were detected?
- What are the limitations of tool?
- *Stack* vs. *heap* vs. *static* memory issues detected
- *Local* vs. *global* (function) issues detected
- *Static analysis* vs. *dynamic analysis*
- Why Valgrind-memcheck missed some memory leaks detected by Cppcheck?
  – What you need to change so memcheck will find it?
  – How this is relevant to test coverage?

FUZZING

Pre-prepare

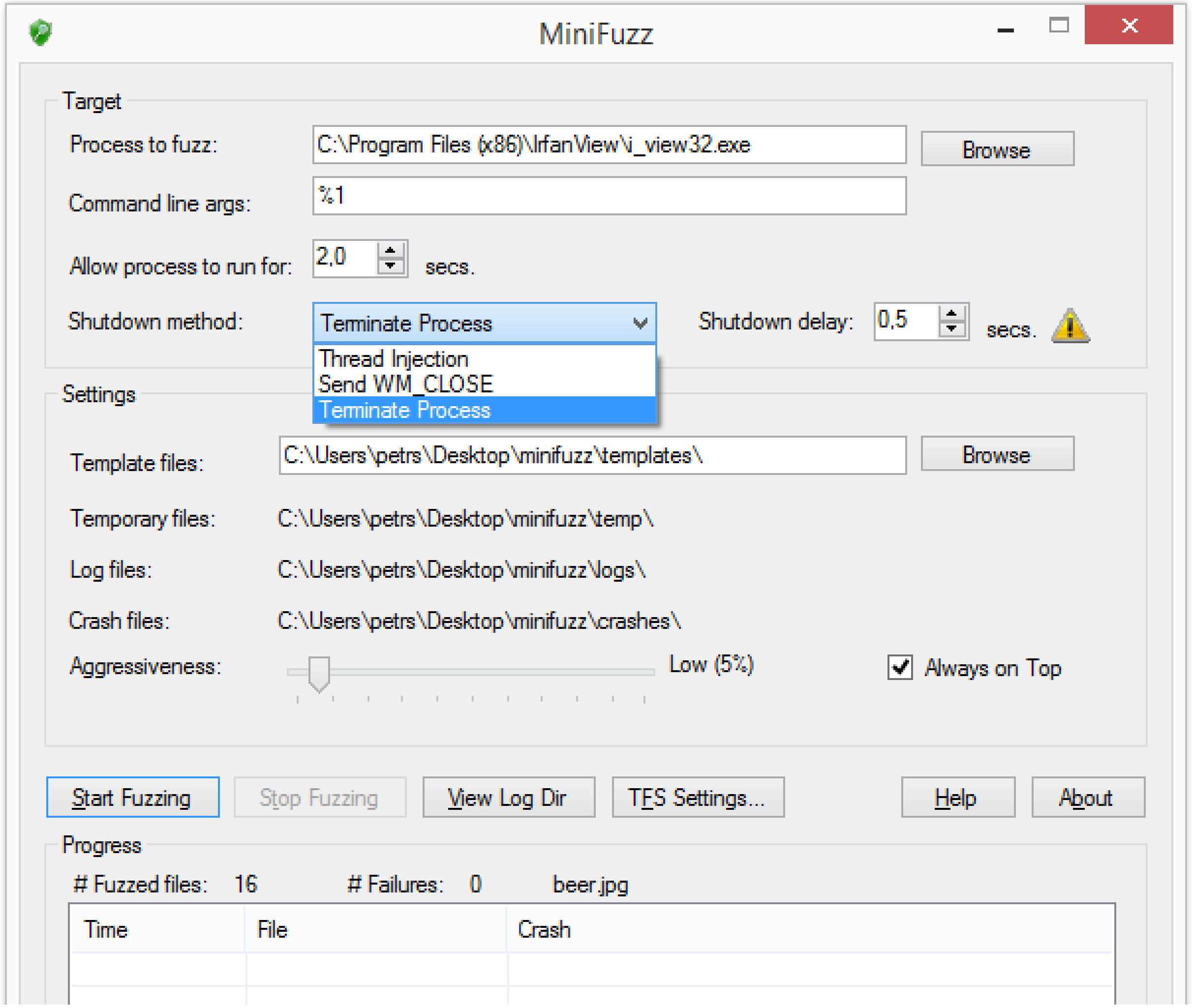
- Download zip with all binaries and data from IS

- Optional: if you need WinDbg, use:
  - Standalone Debugging Tools for Windows (WinDbg) is enough
  - https://msdn.microsoft.com/en-us/windows/hardware/hh852365

Microsoft's SDL MiniFuzz File Fuzzer

- Application input files fuzzer
  - http://www.microsoft.com/en-us/download/details.aspx?id=21769
- Templates for valid input files (multiple)
- Modify valid input file (randomly, % aggressiveness)
- Run application with partially modified inputs
- Log resulting crash (if happen)
  - exception, CPU registers...
- Video overview
  - http://msdn.microsoft.com/en-us/security/gg675011.aspx

Microsoft's SDL MiniFuzz File Fuzzer



MiniFuzz

Target

Process to fuzz: C:\Program Files (x86)\IrfanView\i_view32.exe

Command line args: %1

Allow process to run for: 2,0 secs.

Shutdown method: Terminate Process

Shutdown delay: 0,5 secs.

Settings

Template files: C:\Users\petrs\Desktop\minifuzz\templates\

Temporary files: C:\Users\petrs\Desktop\minifuzz\temp\

Log files: C:\Users\petrs\Desktop\minifuzz\logs\

Crash files: C:\Users\petrs\Desktop\minifuzz\crashes\

Aggressiveness: Low (5%)

☑ Always on Top

Progress

Fuzzed files: 16 # Failures: 0 beer.jpg

Time	File	Crash

Play with SDL MiniFuzz

- Goal: crash IrfanView v1.75 (1996)
  - Image file goes as first argument

1. Select target executable (bin\I_VIEW32_1.75.exe)
2. Copy at least one input file into template folder
   - Template files directory, copy data\Icon_ManBig_128.GIF from zip file
3. Set proper shutdown method (experiment, Terminate Process)
4. Run and observe crashes (log, crashing images)

Play with SDL MiniFuzz – bonus tasks

- Where can you find images that caused crash?
- Bonus: Can you increase the speed of testing?
- Bonus: What is the impact of aggressiveness?
- How can you test your application?
- How can you test VLC with 1.9GB movie?

- Note: MS SDL requires 100k runs without failure

Radamsa fuzzer

- *"…easy-to-set-up general purpose shotgun test to expose the easiest cracks…"*
  - https://gitlab.com/akihe/radamsa
- Just provide input files, all other settings automatic
  - **cat** file **|** radamsa **> file.fuzzed**

```
>echo "1 + (2 + (3 + 4))" | radamsa -n 4
 1 + (2 + (2 + (3 + 4?)
 1 + (2 + (3 +?4))
 18446744073709551615 + 4)))
 1 + (2 + (3 + 170141183460469231731687303715884105727))
```

- On Windows: use radamsa-0.4_win.exe from IS
- On Linux: Download from https://github.com/aoh/radamsa/releases

Radamsa as file fuzzer (XML example)

- `radamsa -o fuzz_%n.xml -n 10 *.xml`
  - Takes file template from `*.xml` file(s)
  - Generates given number (10) of fuzzed files (-n 10)
- Testing your application
  1. Collect valid input file(s) for target app into *.xml file(s)
  2. Run Radamsa to create large number of fuzzed files
  3. Run your application with fuzzed input file and monitor
     - Custom code for monitoring (e.g., crash detected by success in acquire of named mutex)
     - WinDbg for monitoring, parse output log file
- Example:
  - use data\books.xml as template
  - generate 10 fuzzed variants and inspect the result in text editor

Questions for Radamsa

- In what is SDL MiniFuzz better than Radamsa?
- Why is Radamsa better in fuzzing text files?
- How can you combine Radamsa and MiniFuzz?

- Can you fuzz vulnserver.exe?
  - 127.0.0.1:9999
- How to test server/client in stateful protocol?

Assignment 2: Code buggy (as hell)

- Create your own C/C++ compile-able program
  - 1kB size at maximum (STRICT REQUREMENT!)
  - Including main function, must compile under both gcc/g++ & MSVC
- Insert as many (>>10) different vulnerabilities
  - buffer overflow, string format problems, memory corruptions (stack / heap) as you can
  - Only principally different bugs will be counted
  - Document bugs inserted/found in separate report
- Run various static and dynamic checkers on your program
  - Compiler (+flags), CppCheck, PREFast, suitable fuzzer…

Assignment 2: Code buggy (as hell)

- Produce short (4xA4) text with description of your solution
  - Create report from results obtained by running the analysis tools
  - Create table with all problems inserted and if detected by given tool
    - Rows == Problems, Columns == tool result
  - Highlight false positives and false negatives (and discuss why)
- What to submit
  - Source code of buggy application
  - Results from analysis tools
  - Report with the description of your solution
- When and where to submit
  - Submit **before 10.10.2019 23:59** into IS HW vault
  - Soft deadline: -1.5 points for every started 24 hours

FORM GROUP, SELECT PROJECT, BOOK WITH ME, START WITH STATIC ANALYSIS SEE IS PA193 → LECTURES → PA193_PROJECTS_2019.PPTX

OPTIONAL, OWN WORK – NETWORK FUZZING, PEACH FRAMEWORK

Radamsa as fuzzing client – test server

- `radamsa -o ip:80 -n inf samples/*.http-req`
  - Connects as client to server at ip:80, runs infinitelly (-n inf)
  - Takes template inputs from `*.http-req` file(s)
  - Send fuzzed input to server and store it into `fuzz_%n.http-req` files
- Testing you server
  1. Capture valid request for your client to server (e.g., GET request) and store into *.http-req file(s)
  2. Run (repeatedly) Radamsa as TCP client
  3. Monitor behaviour of your server under Radamsa requests
- Test against astrolight.cz (use data\astrolight.http-req)
- Important: always tests only your servers or with the owner consent!!!

Radamsa as fuzzing server – test client

- `radamsa -o fuzz_%n.http-resp :8888 -n inf samples/*.http-resp`
  - Starts as server on port 8888, runs infinitelly (-n inf)
  - Takes template inputs from `*.http-resp` files
  - Return fuzzed input to connecting client
- Testing you client
  1. Capture valid responses from your server (e.g., HTML page) and store into *.http-resp file(s)
     - Use data\string.http-resp as template
  2. Run Radamsa as server (see above)
  3. Run your client (repeatedly, browser) and monitor its behaviour

Vulnerable server (vulnServer.exe)

- Only for Windows
  - for Linux, consider OWASP Mutillidae
- Vulnerable server inside VulnServer.zip
- Run it – waits for connection
- Connect via telnet (putty)
  - host=localhost port=9999
- Type HELP

- Server is vulnerable, we will try to crash it by fuzzing

Peach – fuzzing vulnerable network server

1. Prepare Peach Pit file (example hter_pit.xml)
   - data model, state model, agent…
2. Run Peach Agent (first terminal)
   - `peach -a tcp`
3. Run Peach fuzzing (second terminal)
   - `Peach hter_pit.xml TestHTER`
   - Wait for detected crash (fault)
4. Inspect directory with crash logs
   - *Logs\hter_pit.xml_TestHTER_???\Faults\EXPLOITABLE_???\*
5. Debug crash using fuzzed data from crash log
   - E.g., *1.Initial.Action.bin, 2.Initial.Action_1.bin…*

```
<DataModel name="DataHTER">
 <String value="HTER " mutable="false" token="true"/>
 <String value=""/>
 <String value="\r\n" mutable="false" token="true"/>
</DataModel>



  <Action type="input" ><DataModel ref="DataResponse"/></Action>
  <Action type="output"><DataModel ref="DataHTER"/></Action>
  <Action type="input" ><DataModel ref="DataResponse"/></Action>
 </State>
</StateModel>

<DataModel name="DataResponse">
 <String value=""/>
</DataModel>


 <!-- Run and attach windbg to a vulnerable server -->
 <Monitor class="WindowsDebugger">
   <Param name="CommandLine" value="vulnserver.exe"/>
   <Param name="WinDbgPath" value="c:\Program Files (x86)\Windows Kits\8.1\Debuggers\x64\" />
 </Monitor>
</Agent>



 <StateModel ref="StateHTER"/>
 <Publisher class="TcpClient">
  <Param name="Host" value="127.0.0.1"/>
  <Param name="Port" value="9999"/>
 </Publisher>



 </Logger>
```

Model of input data
‘HTER *anything* \r\n’

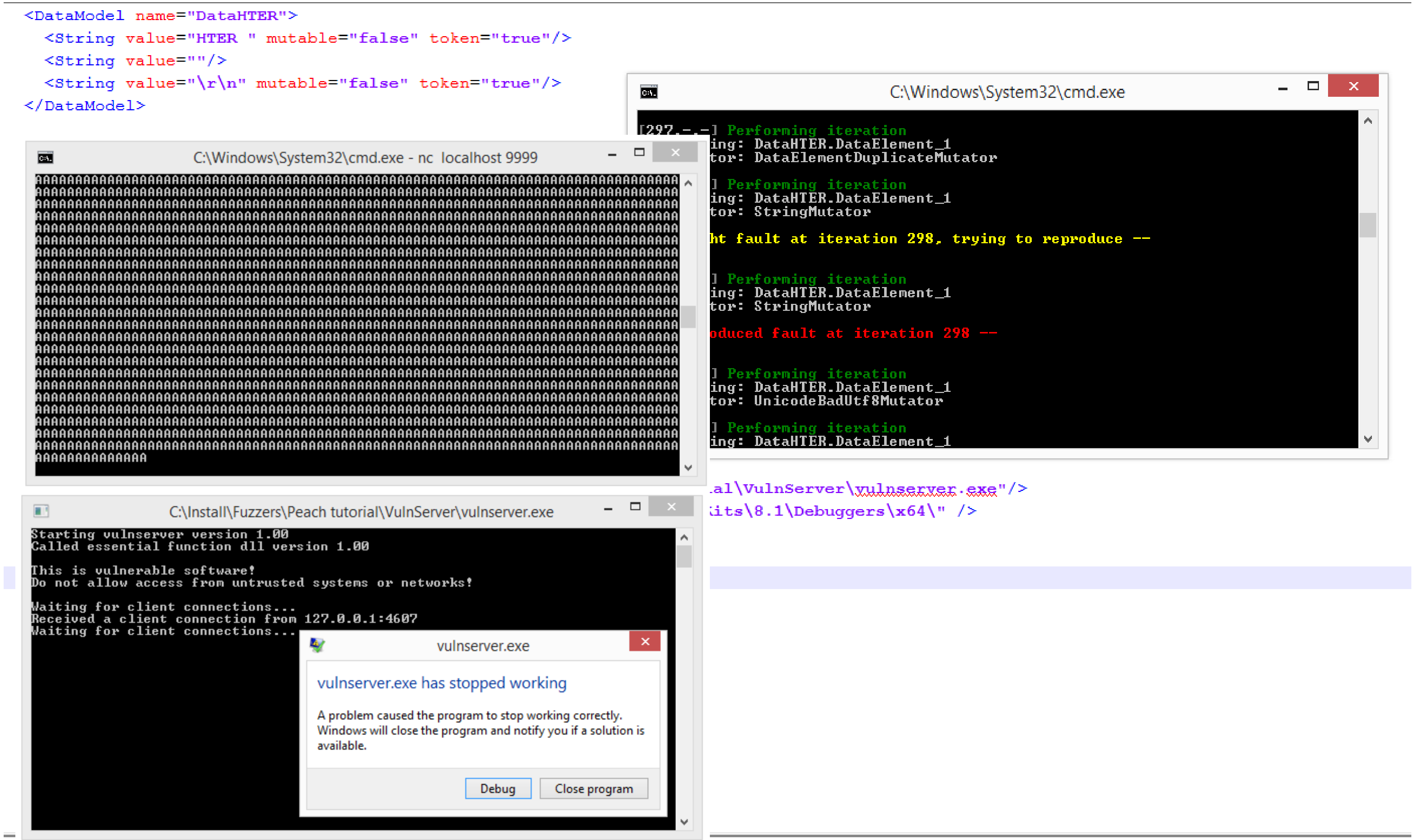
1. Read any string
2. Send fuzzed input
3. Read any string

Agent responsible for starting target application with debugger connected

Test scenario with specified settings

How to communicate with target application

How to store results



```
<DataModel name="DataHTER">
  <String value="HTER " mutable="false" token="true"/>
  <String value=""/>
  <String value="\r\n" mutable="false" token="true"/>
</DataModel>
```

```
AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
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AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
AAAAAAAAAAAAAA
```

```
[297,-,-] Performing iteration
ing: DataHTER.DataElement_1
tor: DataElementDuplicateMutator

] Performing iteration
ing: DataHTER.DataElement_1
tor: StringMutator

ht fault at iteration 298, trying to reproduce --

] Performing iteration
ing: DataHTER.DataElement_1
tor: StringMutator

oduced fault at iteration 298 --

] Performing iteration
ing: DataHTER.DataElement_1
tor: UnicodeBadUtf8Mutator

] Performing iteration
ing: DataHTER.DataElement_1
```

```
.al\VulnServer\vulnserver.exe"/>
its\8.1\Debuggers\x64\" />
```

```
Starting vulnserver version 1.00
Called essential function dll version 1.00

This is vulnerable software!
Do not allow access from untrusted systems or networks!

Waiting for client connections...
Received a client connection from 127.0.0.1:4607
Waiting for client connections...
```

vulnserver.exe has stopped working

A problem caused the program to stop working correctly. Windows will close the program and notify you if a solution is available.

Example from http://rockfishsec.blogspot.ch/2014/01/fuzzing-vulnserver-with-peach-3.html

Questions for Peach

- Is Peach able to fuzz stateful protocols?
- Is Peach able to specify custom data format?
- Does Peach monitor only application crash?

```
# powershell.exe -ExecutionPolicy Bypass ./ff_radamsa.ps1 beer.jpg irfan.exe 10
$fileTemplate = $args[0]
$fileTemplateResolved = Resolve-Path $args[0]
$targetApp = Resolve-Path $args[1]
$totalRuns = $args[2]
$radamsa= Resolve-Path "radamsa.exe"
$count=1
while ($count -le $totalRuns) {
  $fuzzFileName = "fuzz-" + $count + "_" + $fileTemplate
  $fuzzFileWindbRes = $fuzzFileName + ".wdbg.log"
  # run Radamsa to generate single fuzzed file
  & $radamsa -o $fuzzFileName $fileTemplate
  Write-Host "New file $fuzzFileName generated"
  # run target application with fuzzed file as argument under WinDbg monitoring
  & windbg -logo $fuzzFileWindbRes $targetApp $fuzzFileName
  # wait some time
  Start-Sleep -s 2
  # terminate target program inside windbg
  $a = Get-WmiObject win32_process -Filter "name = 'windbg.exe'"
  $a | % {Invoke-WmiMethod -Name terminate -InputObject $_ | out-null}
  # TODO: parse output log files *.wdbg.log
  $count++
}
```

Own work – fuzz student-selected app

- Find any application on internet and fuzz it
  - Make sure you can execute it on your machine
  - Various image and movie players are good targets
  - Download some old(er) release – more bugs possibly
- Try to fuzz it to crash (MiniFuzz, Radamsa)
- Inspect results and discuss