Fuzzing Apache OpenOffice
An Approach to Automated Black-box Security Testing

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Who is Rob?

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Talk Outline

1) Intro
2) Fuzzing Theory
3) Previous Fuzzing with OpenOffice.org
4) Current Approach
5) Results with AOO 4.1
6) Future Opportunities
7) The End
What is fuzzing?

- Feeding a program random data in order to induce faults.
- Black box fuzzing assumes nothing about the expectations of the program.
- White box fuzzing knows about the underlying formats and protocols.
Theoretical Basis

http://upload.wikimedia.org/wikipedia/commons/f/f1/Monkey-typing.jpg
In January 2000, with my Permutator tool, used to test the C++ port of Apache Xalan!

Take input XSLT, make random changes, run Xalan in a process with custom debugger attached, catch runtime faults, repeat.

Same basic idea has been elaborated on over the years, but that's essentially it.
Historically a strength of OpenOffice

We have a good historical record of reducing the number of exploitable crashes.

http://dankaminsky.com/2011/03/11/fuzzmark/
Toolset

- Bz-attachment-extract.py (custom)
- PeachMinset (from Peach Fuzzer)
- Failure Observation Engine 2.0 (from CERT)
- VMWare/Windows 7 64-bit/AOO 4.1 Beta
void foo()
{
    byte x[9];
    memcpy(x,"123456789XYZ");
}

void main(int argc, char*argv[])
{
    foo();
}
What we're looking for

```c
void foo()
{
    byte x[9];
    memcpy(x,"123456789XYZ");
}

void main(int argc, char*argv[])
{
    foo();
}
```

Stack in foo immediately before call to memcpy:

- `x[]` 9 bytes
- `ret=@main` 4 bytes
- `argv` 4 bytes
- `argc` 4 bytes
void foo()
{
    byte x[9];
    memcpy(x,"123456789WXYZ");
}

void main(int argc, char*argv[])
{
    foo();
}

Stack in foo immediately after call to memcpy:

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>x[]</td>
<td>123456789</td>
</tr>
<tr>
<td>ret</td>
<td>WXYZ</td>
</tr>
<tr>
<td>argv</td>
<td>4 bytes</td>
</tr>
<tr>
<td>argc</td>
<td>4 bytes</td>
</tr>
</tbody>
</table>

Return address corrupted.
## Ancient File Formats

Often processed like:

- Switch on record type
- Malloc the specified size
- Cast to a pointer to appropriate struct based on type
- Repeat

Very efficient... when the data is correct.

<table>
<thead>
<tr>
<th>Record Type</th>
<th>Record Length</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
A Large State Space

5 byte file has $256^5 \sim 10^{12}$ ways to mutate it

But a typical document is 100KB or more in length $\sim 10^{2466037}$ combinations

We need to be smart about this or we'll be here all night!
Defect Find Rate (assuming uniform defect distribution)

Not a very encouraging dynamic.
What we usually see in QA

- Tests executed
- Defects found
functionality lower in the tree is exercised more frequently and the defects there are found faster.
A Key Insight

- We can mutate existing documents taken from our Bugzilla
  - We have a large number of documents created over many years in many versions of OpenOffice
  - Broad feature coverage
  - Emphasizes documents that are in product areas that are currently or have been buggy. (Cockroach theory)
bz-attachment-extract


- Hard-coded to use the AOO instance of BZ, but should be easily adaptable.
- "Nice", pauses 15 seconds between each download.
- Works off a text file of issue ID's which you can easily get from exporting a CSV from a BZ query.
- Caches the issue's XML so repeated invocations will faster if hitting the same issue.
  - But currently no check for staleness.
What did we get?

- 9,602 total files
- 1,328 doc files
- 425 ppt files
- 369 xls files
- 11,211 binary image files

Most were screenshots not problem images.
Second Insight

- Redundancy makes this inefficient
  - Do we really want to test 10,000 JPG files but only 4 SVM image files?
- We could weight file extensions equally
  - But that fails to account for different complexity of formats
- Solution is to maximize code coverage, pick the minimum set of test files that covers the same code as the entire set of files.
PeachMinSet

- Part of Peach Fuzzer: http://peachfuzzer.com/
- Loads each file, doing an instruction trace and then post-processes the traces to tell you what the minimum file set is.
- A bit temperamental. Required some duct tape and WD40 to work with AOO. Contact me if you want the gory details.
Minset Results

- 225/1328 doc files = 17%
- 144/425 ppt files = 34%
- 46/369 xls files = 40%
- 234/11,211 binary image files = 2%

Total 649 of 13,333 = 5%, so overall a 20x improvement
Failure Observation Engine

- Windows Fuzzing Framework from CERT
  
  [link: "http://www.cert.org/vulnerability-analysis/tools/foe.cfm"]

- A sister project for Linux, Basic Fuzzing Framework (BFF) is also available: [link: "http://www.cert.org/vulnerability-analysis/tools/bff.cfm"]
Basic FOE Workflow

- Take a seedfile and apply specified fuzzer to it
- Pass fuzzed file to AOO command line
- If a fault is detected then hook in debugger
  - If crash is dupe then skip, else:
    - Pass crash details onto Microsoft's !exploitable to classify the crash
    - Write out crash dump plus the fuzzed and original file
    - Optionally, try to “minimize” the fuzzed file to create a minimal test case.
- FOE learns which files and fuzzing parameters lead to the most crashes.
• 4 VMs ran for 1 week
• ~10 tests/minute for each VM
• 4*10*7*24*60 = ~ 400K tests
• Many crashes, over 70 classified as EXPLOITABLE by !exploitable.
• But only 4 root causes, which are fixed in the 4.1 GA release.

I can provide more detail in Denver on the actual fuzzing results if AOO 4.1 is released by then.
• Fuzzing is only one approach, but is not a silver bullet.
• Static analysis, e.g., Coverity is another, complementary, tool.

• We might also consider retiring some of the rarely used binary formats to reduce exposure, or at least make them optional at install time.
Time Permitting: Random Observations
I assume this all makes sense to developers. But to users?
Fuzzing a Raster Image

It is like shooting a jellyfish!
Fuzzing XML

- Most random mutations of XML files cause the file to be rejected. We need to be clever to induce faults in processing of ODF and OOXML, e.g.:
  - Replace numeric attribute values with 0, -1, 1, $2^{16}$-1, $-2^{16}$, NaN, INF, -INF
  - Replace string attribute values with "", "      ", a large string (16K)
  - Interchange xml:id and idref's
  - Interchange two subtrees
  - Replace character data
  - Schema-directed fuzzing?
Headless Execution

- Idea is to increase test execution rate
- Focus on parsing code, not layout code
- But maybe faults are in layout code also?
- Possibilities for unit-level fuzzing as well
The End