DENIM GROUP

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Static Analysis Techniques for Testing Application Security

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February 18th, 2008

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Agenda

- What is Application Security?
- What is Static Analysis?
  - *Static versus Dynamic*
  - *Overview*
- Different Approaches
- Examples of Static Analysis Tools
  - *FindBugs (Java)*
  - *PMD (Java)*
  - *FxCop (.NET)*
  - *XSSDetect (.NET)*
- Process Implications
- Questions

What is Application Security?

- Ensuring that applications behave as expected under the entire range of possible inputs
- Really a subset of software correctness/QA – however…
- More typically focused on what an application is NOT supposed to do rather than what it IS supposed to do

What is Static Analysis?

- Analyzing software artifacts in order to gain information about the software
  - *Source code*
  - *Binaries*
  - *Configuration files*
- Analyzing software “at rest”
- Also called “white box testing” and “source code review”

- PLEASE NOTE: Unless otherwise discussed, Static Analysis will refer to Static Analysis being performed by an automated tool

Dynamic Analysis

- Examining running software to see how it behaves under different stimuli
  - *Analyzing request and response patterns*
  - *Checking remotely-detectable configuration settings*

Which to Use?

- Static Analysis
  - *Advantages*
  - *Disadvantages*
- Dynamic Analysis
  - *Advantages*
  - *Disadvantages*
- Actually Making a Decision

Static Analysis Advantages

- Have access to the actual instructions the software will be executing
  - *No need to guess or interpret behavior*
  - *Full access to all of the software's possible behaviors*

Static Analysis Disadvantages

- Require access to source code or at least binary code
  - *Typically need access to enough software artifacts to execute a build*
- Typically require proficiency running software builds
- Will not find issues related to operational deployment environments

Dynamic Analysis Advantages

- Only requires a running system to perform a test
- No requirement to have access to source code or binary code
- No need to understand how to write software or execute builds
  - *Tools tend to be more "fire and forget"*
- Tests a specific, operational deployment
  - *Can find infrastructure, configuration and patch errors that Static Analysis tools will miss*

Dynamic Analysis Disadvantages

- Limited scope of what can be found
  - *Application must be footprinted to find the test area*
  - *That can cause areas to be missed*
  - *You can only test what you have found*
- No access to actual instructions being executed
  - *Tool is exercising the application*
  - *Pattern matching on requests and responses*

Actually Making a Decision

- No access to source or binaries? **Dynamic**
- Not a software developer, don't understand software builds? **Dynamic**
- Performing a "pen test" or other test of an operational environment? **Dynamic**
- None of the previous problems? **Static**
- Really want to do the job right? **Both (and then some…)**

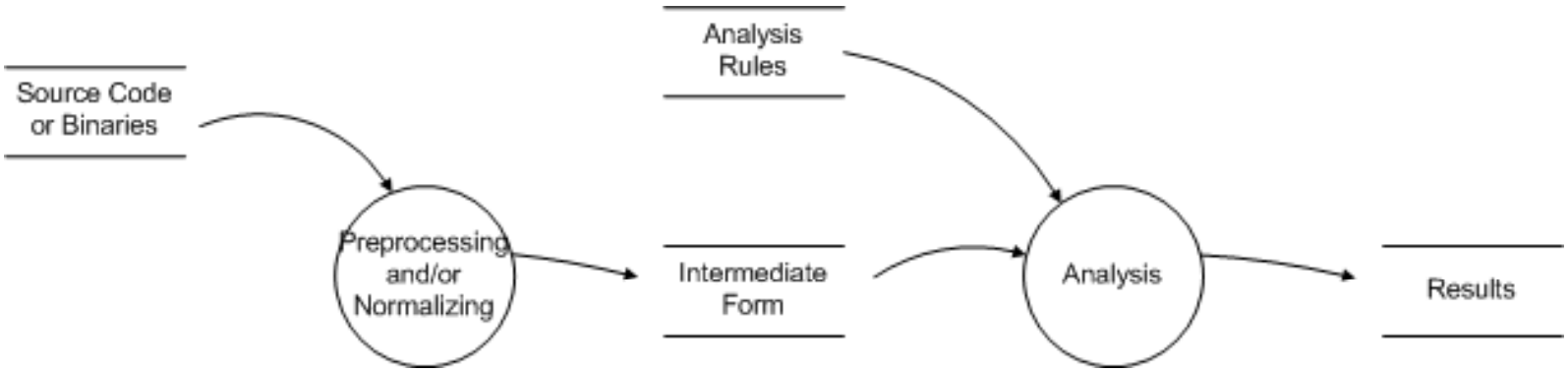
Actually Making a Decision

- In our experience:
- **Information Security** practitioners are more comfortable with the Dynamic Analysis tools
  - *Analog to scanners such as Nessus or ISS*
- **Software Development** practitioners are comfortable with both Static and Dynamic Analysis tools, but can get the most value out of Static Analysis tools
  - *More complete view of the software*
  - *Integration with IDEs is a plus*
- Understand that there are things that tools can find, and things tools can't find. **Running a tool doesn't make you "secure"**

Overview

- General Approach
- Source or Binary?

General Approach



Source or Binary?

- Access to source typically provides more information to the analysis tool than only having access to the binaries
- Advantages of binaries:
  - *More commonly available*
  - *If you dynamically generate binaries based on database schema, etc*

Source or Binary – C/C++

- “Vanilla” C can be reasonably easy to decompile, but…
- C++ and C compiled with compiler optimizations can be challenging to decompile sensibly

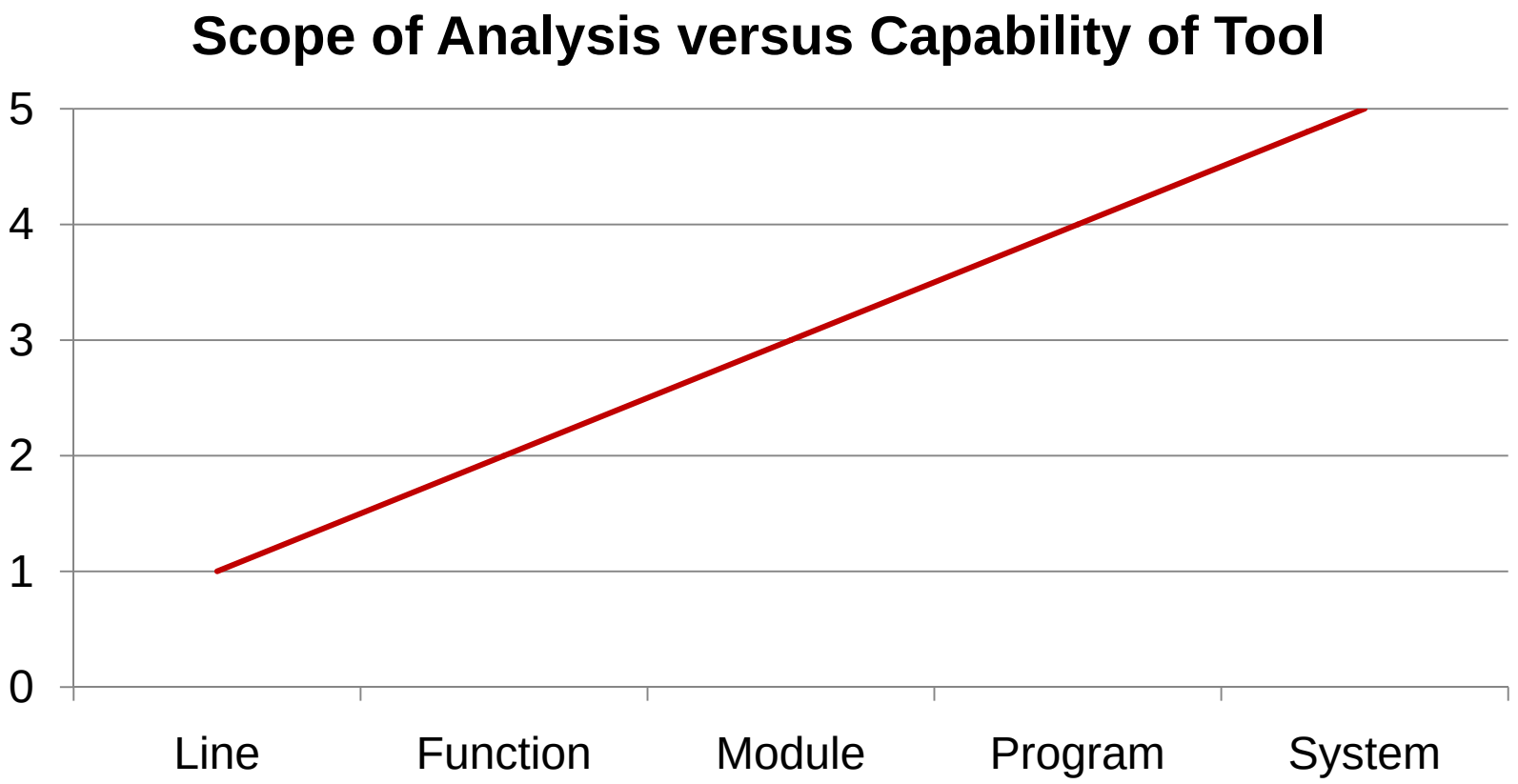
Source or Binary – Java or .NET

- These environments are pretty easy to decompile
  - *"Source" recovery is typically pretty easy*
- Most .NET tools actually use binaries and disassemble them into IL
  - *Thus they only have to have one parser to process IL rather than one for every .NET language*

Different Approaches

- Increasing the scope of analysis increases the capability of the tool to find potential errors
- As scope increases, tools must either effectively prioritize analysis options or risk having excessive runtimes

Scope and Capability



Line Focus

- Like using “grep” to identify banned or suspect function calls
- This was the approach taken by early tools
- Good way to make a quick pass for potential vulnerabilities
  - *Good for targeting manual review*
- Challenging to use on large codebases
- The more “signatures” that are included, the higher the noise to signal ratio will be
  - *Just looking for specific functions*

Line Focus Example

- Rule: gets() is BAD
- Input:

```
my_str = gets();
```

- Result: Flag this line for review
- Pretty basic, but better than nothing

Line Focus: C/C++

- Known “bad” APIs:
  - *strcpy()*
  - *gets()*
  - *scanf()*
  - *sprintf()*

Line Focus: Java

- SQL injection
  - *[Connection].createStatement()*
- XSS
  - *<%=*
- More general parameter tampering:
  - *[HttpServletRequest].getParameter()*
  - *[HttpServletRequest].getParameterValue()*
  - *[HttpServletRequest].getCookies()*
  - *[HttpServletRequest].getHeader()*

Line Focus: .NET

- SQL Injection:
  - *SqlCommand*
- XSS
  - *<%=*
- More general parameter tampering
  - *Request[*
  - *Request.Cookies[*
  - *Request.Headers[*

Two (Crappy) Scripts I Wrote

- dotnetcheck.sh and javacheck.sh
- Implement the checks I mentioned above

Function and Module Focus

- At this point the tool needs to be acting as a compiler
  - *Parse into tokens, determine lexical structure*
- This allows for much more sophisticated analysis
  - *State machines*
  - *Control flow*
  - *Data flow*

Function and Module Focus Example

- Rule: Memory should only be freed once

- Input:

```
void f()
{
    my_mem = malloc(256);
    free(my_mem);
    free(my_mem);
}
```

- Result:
  - *my_mem is marked as allocated*
  - *my_mem is marked as freed*
  - *Flag the second call to free(my_mem) as an issue*

Program and System Focus

- Expanding the scope of inquiry allow tools to find more and more subtle flaws
- Also helps avoid false positives

Dataflow and Taint Tracking

- Track dataflows through the system
  - *Sources and Sinks*
- Attach taint flags to inputs
  - *Web parameters and cookies*
  - *Data read from files*
  - *Environment variables*
  - *Data read from databases*
  - *Data read from web services*
- What type of taint?
  - *From the network*
  - *From a configuration setting*
  - *From a database*
  - *And so on*
- Identify “cleaning” functions

Program and System Focus Example

- Rule:
  - *User-supplied data should never be included in a SQL query without being properly escaped*

Program and System Focus Example (continued)

- Input:

```
public void doGet(HttpServletReqest req, HttpServlet Response resp)
{
    String user = req.getParameter(“username”);
    logStuff(user, “my_page”);
    //    Render out HTML…
}

private logStuff(String user, String location)
{
    Connection con = getConnection();
    Statement stmt = con.createStatement();
    String sql
          = “INSERT INTO log (user, location) VALUES (‘” + user + “’, ‘” + location + “’”
    stmt.executeUpdate(sql);
}
```

Program and System Focus Example (continued)

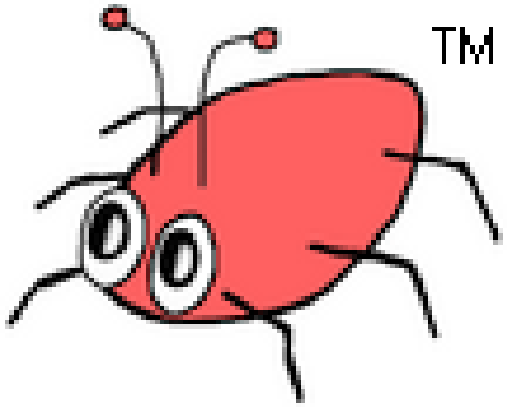
- Result:
  - *Input from getParameter() call is marks user variable as tained (Source)*
  - *Flow of data is traced into the logStuff() method*
  - *sql variable is also marked as tainted when it is concatenated with username parameter*
  - *executeUpdate() is marked as a security issue because it received tainted data (Sink)*

Examples of Static Analysis Tools

- FindBugs (Java)
- PMD (Java)
- FxCop (.NET)
- XSSDetect (.NET)

FindBugs (Java)

- Java-based static analysis tool
- LGPL-licensed
- Originally developed by Dr. Bill Pugh from the University of Maryland
- Intended to find correctness issues, also identifies some security issues



findbugs.sourceforge.net

PMD (Java)

- Java-based static analysis tool
- BSD-licensed
- Lead developers are David Dixon-Peugh and Tom Copeland
- Intended to find correctness and complexity issues, also finds some security issues

pmd.sourceforge.net

FxCop (.NET)

- Microsoft-provided tool for .NET static analysis
- Freely available
- Enforces coding standards (variable naming, etc)
- Similar to FindBugs in its security capabilities

www.gotdotnet.com/Team/FxCop/

XSSDetect (.NET)

- Microsoft-provided tool for .NET static analysis
- Freely available (BETA!)
- Performs data flow analysis to identify Cross Site Scripting (XSS) defects

blogs.msdn.com/ace_team/archive/2007/10/22/xssdetect-public-beta-now-available.aspx

- Based on the Microsoft Research Phoenix framework
  - *For software analysis and optimization*
  - *research.microsoft.com/phoenix/*

Limitations

- Static Analysis tools are a **starting point** for code review. **Not a complete solution**.
- Static Analysis tools (like all automated tools) do not understand what your application is supposed to do
  - *Out of the box rules are for general classes of security defects*
  - *Applications can still have issues with authorization and other trust issues*
  - *Only cover 50% of security defects (Dr. Gary McGraw)*
- False positives can be time consuming to address
- Solutions?
  - *Custom rules can help to add some application specific context*

Process Implications

- Static Analysis tools can provide tremendous benefits
- It is easier to start a new project using a tool than to impose one on an existing system
- I have found that using a Static Analysis tool while developing helps to improve my coding skills
  - *Immediate feedback when mistakes are made*
  - *Learn more about language and platform internals*

Process Implications: Questions

- Who is going to run the tool?
- When is the tool going to be run?
- What will be done with the results?

- Until you can answer these questions, you should not assume that a Static Analysis tool will help you improve security

Additional Resources

- Book: Secure Programming With Static Analysis (Brian Chess and Jacob West)
- Blog: Microsoft Code Analysis and Code Metrics Team Blog
  - *blogs.msdn.com/fxcop/*
- Website: FindBugs publications page
  - *findbugs.sourceforge.net/publications.html*
- Various commercial vendors…

Questions

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