PA193 - Secure coding principles and practices

Static analysis of source code

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CROCS

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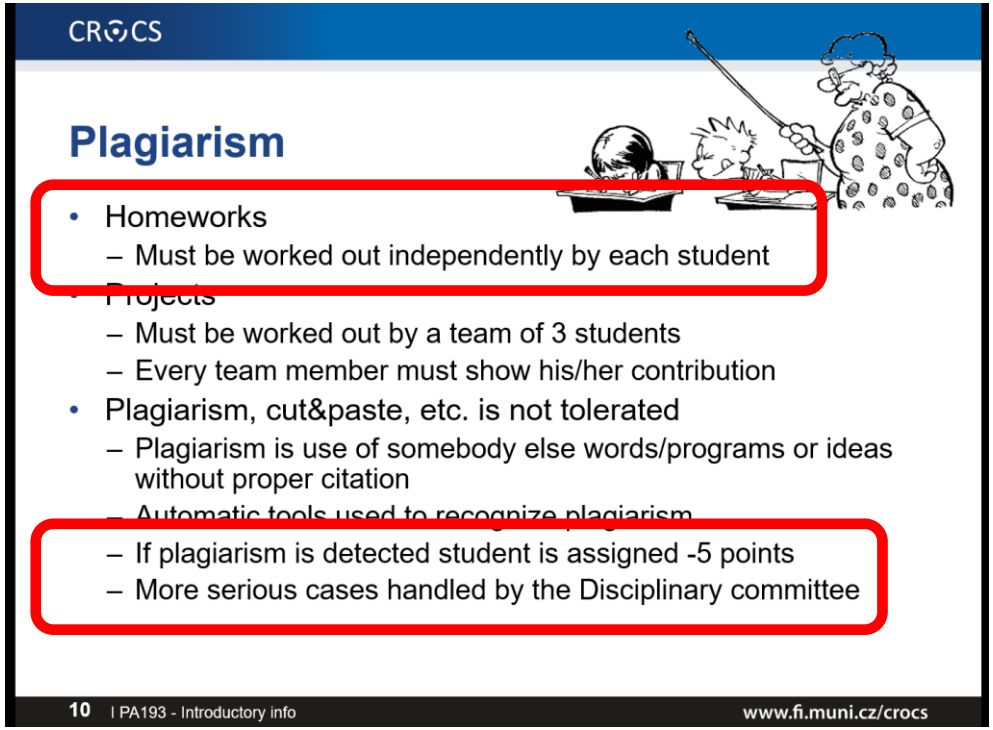
Before we start…

- Homework 1 – currently in progress, till 5.10.
- Project – demonstration at seminar 5.10.
  - repo + Travis + tests



PROBLEM

Cost of insecure software

- Increased risk and failures due to generally increased usage of computers
- Fixing bug in released version is more expensive
  - testing, announcements…
- Liability laws
  - need to notify, settlement...
- Reputation loss
- Cost of defense is decreasing
  - better training (like this course ☺), automated tools, development methods

What is wrong with this code?

```
network_receive(uchar* in_packet, short &in_packet_len); // TLV
uchar* in = in_packet + 3;
short length = make_short(inpacket + 1);

uchar* out_packet = malloc(1 + 2 + length);
uchar* out = out_packet + 3;

memcpy(out, in, length);



network_transmit(out_packet);
```

OpenSSL Heartbeat – “packet repeater”

```
network_receive(uchar* in_packet, short &in_packet_len); // TLV
uchar* in = in_packet + 3; short length = make_short(inpacket + 1);
```

```
unsigned char* in
```


```
uchar* out_packet = malloc(1 + 2 + length);
uchar* out = out_packet + 3;

memcpy(out, in, length);
```

```
unsigned char* out
```


```
network_transmit(out_packet);
```

Problem?

```
network_receive(uchar* in_packet, short &in_packet_len); // TLV
uchar* in = in_packet + 3;
```

unsigned char* in


```
uchar* out_packet = malloc(1 + 2 + length);
uchar* out = out_packet + 3;

memcpy(out, in, length);
```

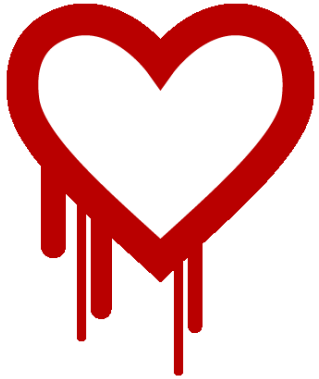
in_packet_len != length + 3

unsigned char* out

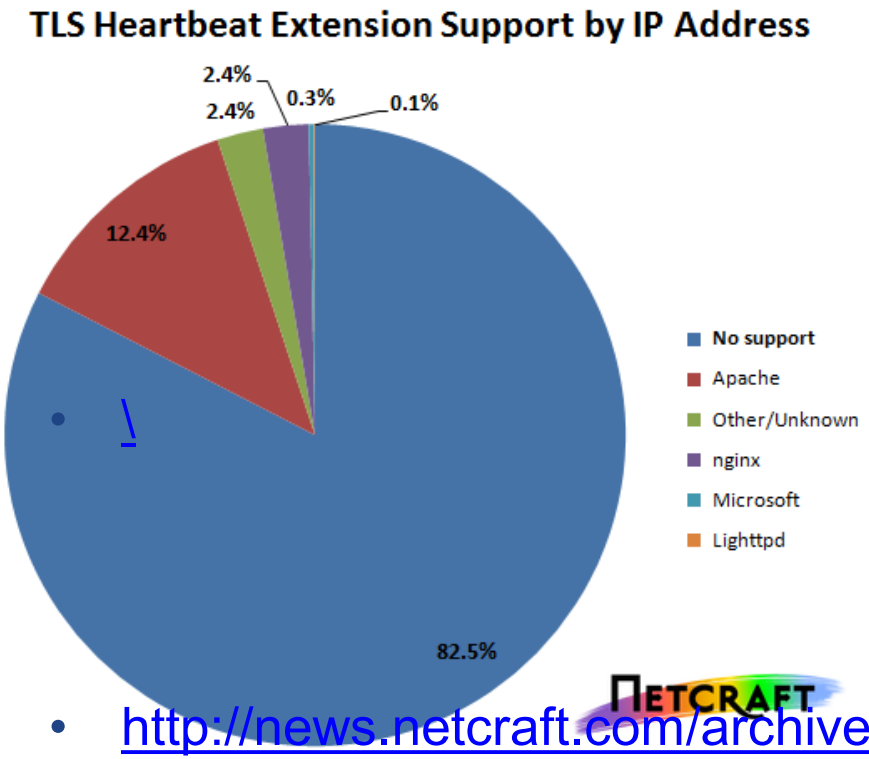

```
network_transmit(out_packet);
```

Problem!

How serious the bug was?



17% SSL web servers (OpenSSL 1.0.1)
Twitter, GitHub, Yahoo, Tumblr, Steam, DropBox, DuckDuckGo…
https://seznam.cz, https://fi.muni.cz …



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- http://news.netcraft.com/archives/2014/04/08/half-a-million-widely-trusted-websites-vulnerable-to-heartbleed-bug.html

Defensive programming

- Term coined by Kernighan and Plauger, 1981
  - *"writing the program so it can cope with small disasters"*
  - talked about in introductory programming courses
- Practice of coding with the mind-set that errors are inevitable and something will always go wrong
  - prepare program for unexpected behavior
  - prepare program for easier bug diagnostics
- Defensive programming targets mainly unintentional errors (not intentional attacks)
  - But increasingly given security connotation

“Security features != Secure features”

- *“Security features != Secure features”*
  - *Howard and LeBlanc, 2002*
- *“Writing security features, although important, is only 10% of the workload of creating secure code. The other 90% of the coding work is meant to ensure that all non-security codebase is secure.”*
  - *Sullivan, Balinsky, 2012*
- *“Reliable software does what it is supposed to do. Secure software does what it is supposed to do, and nothing else.”*
  - *Ivan Arce*

STATIC AND DYNAMIC ANALYSIS

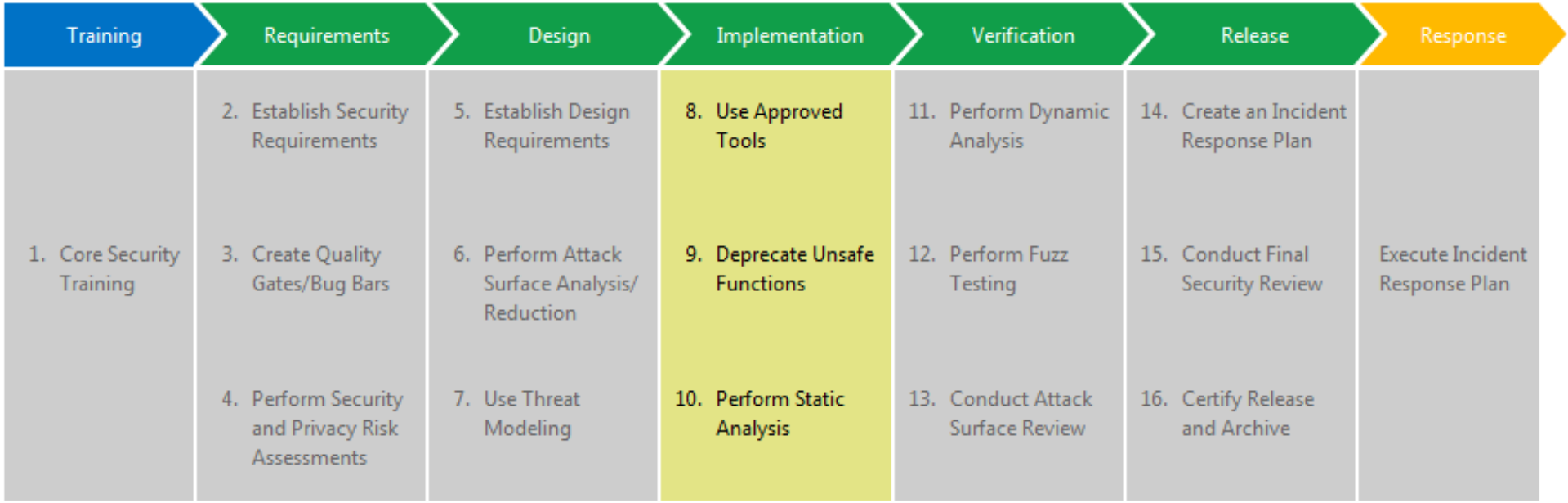
How to find bugs in code?

- Manual “dynamic” testing
  - running program, observe expected output
- Manual analysis of code
  - code review, security code review
- Automated analysis of code without compilation
  - static analysis (pattern matching, symbolic execution)
- Automated analysis of code with execution
  - dynamic analysis (running code)
- Automated testing of inputs (fuzzing)

Approaches for automated code review

- Formal methods (mathematical verification)
  - requires mathematical model and assertions
  - often requires modeling the system as finite state machine
    - verification of every state and transition
    - (outside the scope of this course, consider IA169)
- Code metrics
  - help to identify potential hotspots (complex code)
  - e.g., Cyclomatic complexity (number of linearly indep. paths)
- Review and inspection
  - tries to find suspicious patterns
  - automated version of human code review

Microsoft's Secure Development Lifecycle



Taken from http://www.microsoft.com/security/sdl/process/implementation.aspx

Cigital Touchpoints methodology

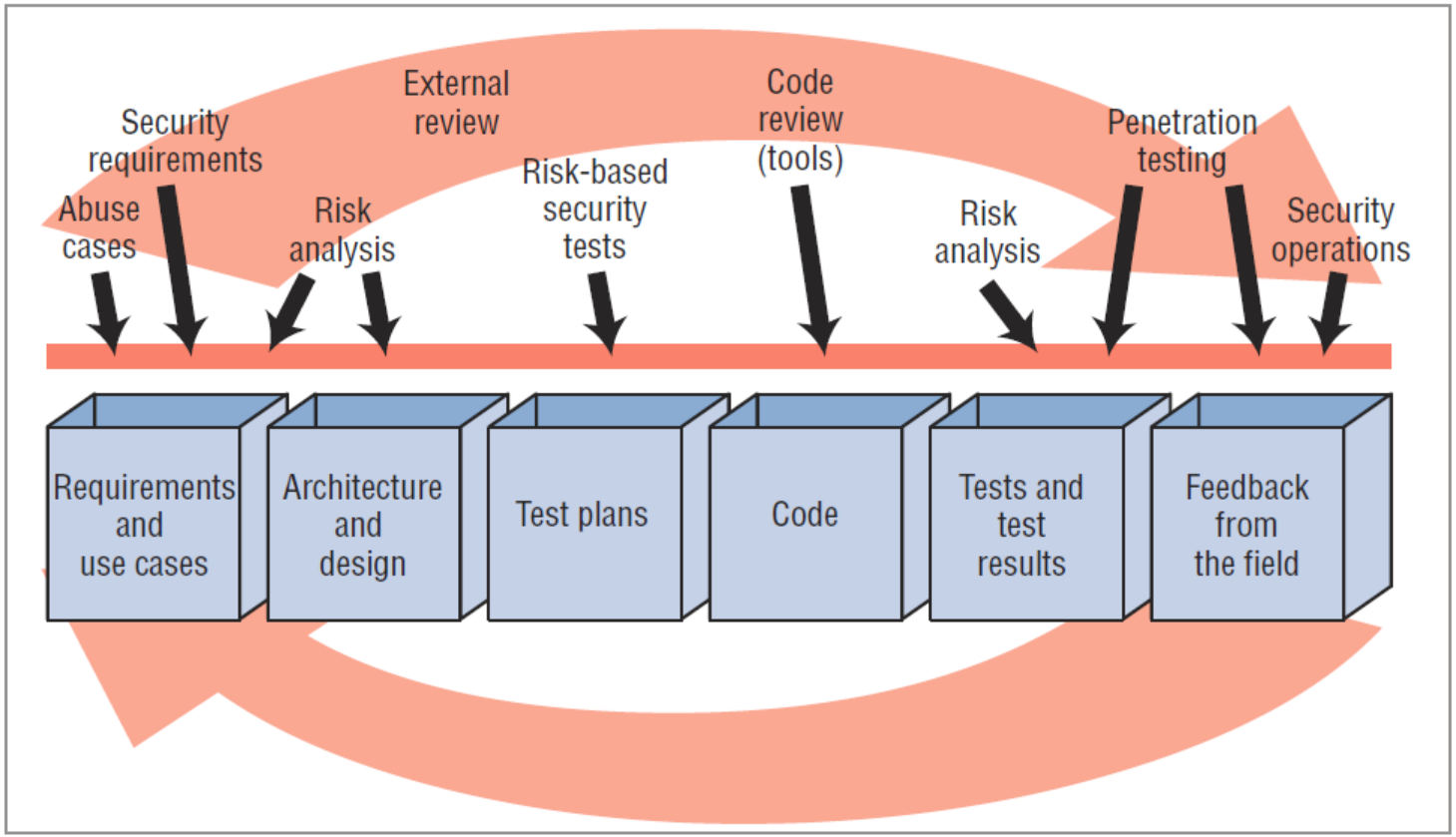
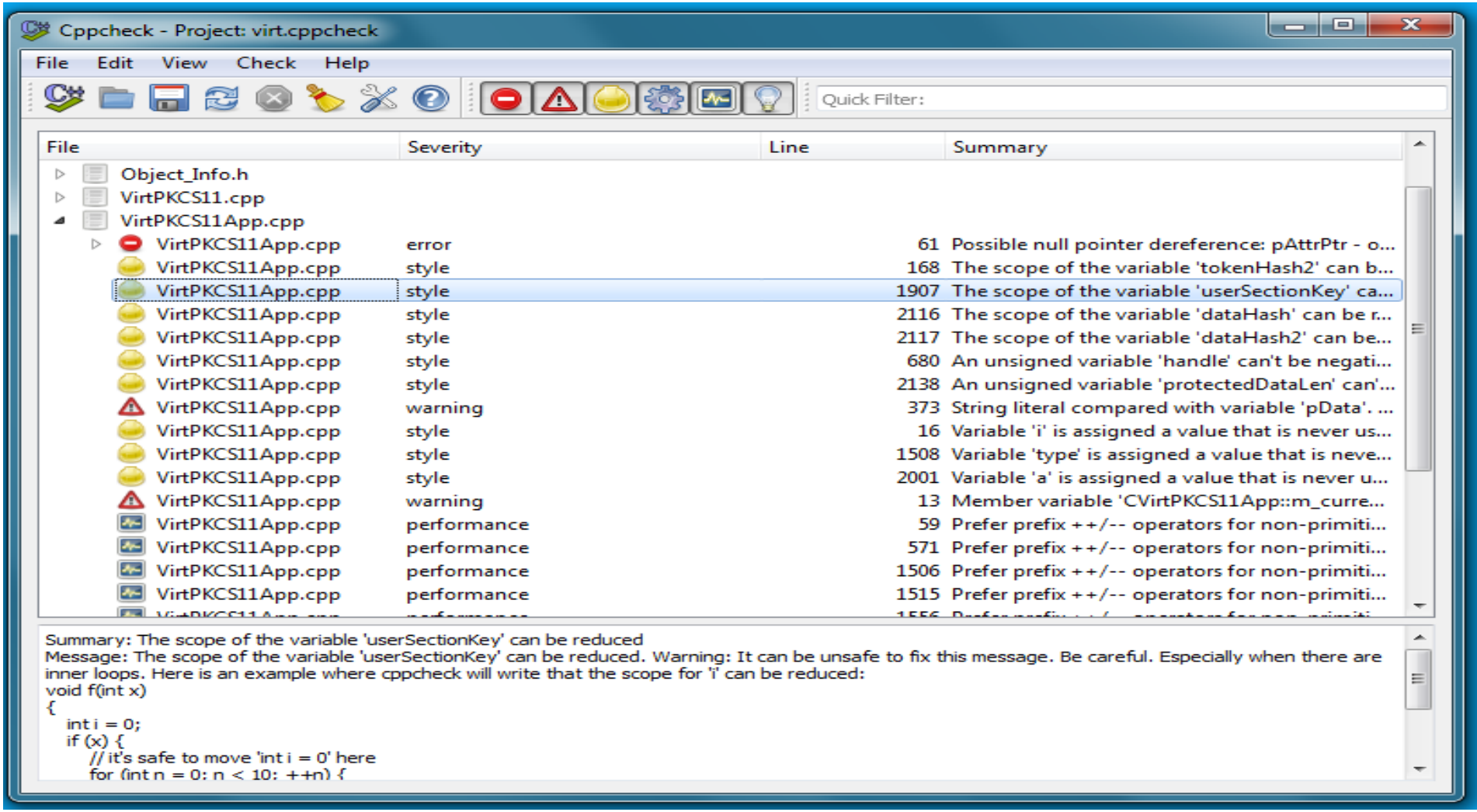


Figure 1. The Cigital Touchpoints methodology. Software security best practices (arrows) applied to various software artifacts (boxes).

Static vs. dynamic analysis

- Static analysis
  - examine program's code without executing it
  - can examine both source code and compiled code
    - source code is easier to understand (more metadata)
  - can be applied on unfinished code
  - manual code audit is kind of static analysis
- Dynamic analysis
  - code is executed (compiled or interpreted)
  - input values are supplied, internal memory is examined

Example of output produced by analyzer



Types of static analysis

- Type checking – performed by compiler
- Style checking – performed by automated tools
- Program formal verification
  - annotations & verification of specified properties
- Bug finding / hunting
  - between style checking and verification
  - more advanced static analysis
  - aim to infer real problem, not only pattern match
- Security Review
  - previous possibilities with additional support for review

Type checking

- Type checking – performed by compiler
  - errors against language rules prevents compilation
  - warnings usually issued when problematic type manipulation occur
  - false positives possible (short=int=short), but don't ignore!
- Security problems due to wrong types
  - string format vulnerabilities
  - type overflow → buffer overflow
  - data loss (bigger type to smaller type)
- More on type checking later with compiler warnings

Style checking

- Style checking – performed by automated tools
  - set of required code rules
- Separate tools
  - MS style checker
  - Unix: lint tool (http://www.unix.com/man-page/FreeBSD/1/lint)
  - Checkstyle
  - PMD (http://pmd.sourceforge.net/)
  - Google C++ style checker: C++lint
    - http://google-styleguide.googlecode.com/svn/trunk/cppguide.xml
    - http://google-styleguide.googlecode.com/svn/trunk/cpplint/cpplint.py
- Compiler warnings `gcc -Wall gcc -Wextra`

Bug finding

- No language errors != secure program
  - finding bugs, even when language permits it
- Examples:
  - Buffer overflow possible?
  - User input formatted into system() call?
  - Hard-code secrets?
- Tool must keep false positives low
  - do not report as a bug something which isn't
  - there is simply too many potential problems
- Tools: FindBugs, PREfast, Coverity...

Security analysis and review

- Usage of analysis tool to perform security review
  - Usually multiple tools are used during the process
- Difference between compiler (e.g., gcc) and additional tool (e.g., cppcheck)
  - Compiler must never report error that isn't (lang. standard)
  - Compiler must report low # of false warning (as used by normal "uneducated" developers)
  - Tool executed for automatic reporting should have low # of false warnings (otherwise untrusted)
  - Tool executed during manual code review / pentest can have higher # of false warnings (filtered by expert)

BEFORE DIGGING TO CONCRETE TOOLS…

Static analysis limitations

- Overall program architecture is not understood
  - sensitivity of program path
  - impact of errors on other parts
- Application semantics is not understood
  - Is string returned to the user? Can string also contain passwords?
- Social context is not understood
  - Who is using the system? High entropy keys encrypted under short guessable password?

Problem of false positives/negatives

- False positives
  - errors reported by a tool that are not errors in fact
  - too conservative analysis
  - inaccurate model used for analysis
  - annoying, more code needs to be checked, less readable output, developers tend to have as an excuse
- False negatives
  - real errors NOT reported by a tool
  - missed problems, missing rules for detection

False positives – limits of static analysis

```
void foo()
{
  char a[10];
  a[20] = 0;
}
```

```
d:\StaticAnalysis>cppcheck example.cpp
Checking example.cpp...
[example.cpp:4]: (error) Array 'a[10]' accessed at index 20, which
                         is out of bounds.
```

- When foo() is called, always writes outside buffer

Should you fixed it even when foo() is not called?

False positives – limits of static analysis

```
int x = 0;
int y = 3;
void foo()
{
  char a[10];
  if (x + y == 2) {
    a[20] = 0;
  }
}
```

problematic assignment
put inside condition

```
d:\StaticAnalysis>cppcheck example.cpp
Checking example.cpp...
[example.cpp:7]: (error) Array 'a[10]' accessed at index 20, which
                         is out of bounds.
```

- For `x + y != 2` false positive
- But analyzer cannot be sure about x & y values

False positives – limits of static analysis

```
const int x = 0;
const int y = 3;
void foo()
{
  char a[10];
  if (x + y == 2) {
    a[20] = 0;
  }
}
```

const added (same for #define)

```
d:\StaticAnalysis>cppcheck example.cpp
Checking example.cpp...
```

```
d:\StaticAnalysis>cppcheck --debug example.cpp
Checking example.cpp...

##file example.cpp
1:
2:
3:
4: void foo ( )
5: {
6: char a@3 [ 10 ] ;
7:
8:
9:
10: }
```

- No problem detected – constants are evaluated in compile time and condition is completely removed

False positives – limits of static analysis

```
void foo2(int x, int y) {
  char a[10];
  if (x + y == 2) {
    a[20] = 0;
  }
}
int main() {
  foo2(0, 3);
  return 0;
}
```

```
d:\StaticAnalysis>cppcheck --debug example.cpp
Checking example.cpp...

##file example.cpp
1: void foo2 ( int x@1 , int y@2 ) {
2: char a@3 [ 10 ] ;
3: if ( x@1 + y@2 == 2 ) {
4: a@3 [ 20 ] = 0 ;
5: }
6: }
7: int main ( ) {
8: foo2 ( 0 , 3 ) ;
9: return 0 ;
10:}

[example.cpp:4]: (error) Array 'a[10]' accessed at index 20,
                         which is out of bounds.
```

- Whole program is not compiled and evaluated

Always design for testability

- *"Code that isn't tested doesn't work - this seems to be the safe assumption."* Kent Beck
- Code written in a way that is easier to test
  - proper decomposition, unit tests, mock objects
  - source code annotations (with subsequent analysis)
- References
  - https://en.wikipedia.org/wiki/Design_For_Test
  - http://www.agiledata.org/essays/tdd.html

BUILD-IN COMPILER ANALYSIS

MSVC flags

```
#include <iostream>
using namespace std;
int main(void) {
  int low_limit = 0;
  for (unsigned int i = 10; i >= low_limit; i--) {
    cout << ".";
  }
  return 0;
}
```

- warning C4018: '>=' : **signed/unsigned** mismatch

Warnings – how compiler signals troubles

- MSVC /W n
  - /W 0 disables all warnings
  - /W 1 & /W 2 basic warning
  - /W 3 recommended production purposes (default)
  - /W 4 recommended for all compilations, ensure the fewest possible hard-to-find code defects
  - /Wall == /W4 + extra
- GCC -Wall, -Wextra
- Treat warnings as errors
  - GCC –Werror, MSVC /WX
  - forces you to fix all warnings, but slightly obscure nature of problem

Recommendations for MSVC CL

- Compile with higher warnings /W4
- Control and fix especially integer-related warnings
  - warning C4018: '>=' : signed/unsigned mismatch
    - comparing signed and unsigned values, signed value must be converted to unsigned
  - C4244, C4389 – possible loss of data because of truncation or signed&unsigned variables operation
- If existing code is inspected, look for
  - `#pragma warning (disable, Cxxxx)` where xxxx is above
- Use compiler /RTC flag

warning C4018: '>=' : signed/unsigned mismatch

- What will be the output of following code?
  - string "x > y"
  - but also compiler warning C4018

```
#include <iostream>
using namespace std;
int main(void) {
  int x = -100;
  unsigned int y = 100;
  if (x > y) { cout << "x > y"; }
  else { cout << "y >= x"; }

  return 0;
}
```

int → unsigned int
-100 → 0xffffff9c

Recommendations for GCC

- GCC –Wconversion
  - warn about potentially problematic conversions
  - fixed → floating point, signed → unsigned, ...
- GCC –Wsign-compare
  - signed → unsigned producing incorrect result
  - **`warning: comparison between signed and unsigned integer expressions [-Wsign-compare]`**
  - http://stackoverflow.com/questions/16834588/wsign-compare-warning-in-g provides example of real problem
- Runtime integer error checks using **`-ftrapv`**
  - trap function called when signed overflow in addition, subs, mult. occur
  - but significant performance penalty (continuous overflow checking) ☹

Try this at home!

GCC -ftrapv

```c
/* compile with gcc -ftrapv <filename> */
#include <signal.h>
#include <stdio.h>
#include <limits.h>

void signalHandler(int sig) {
  printf("Overflow detected\n");
}

int main() {
  signal(SIGABRT, &signalHandler);

  int largeInt = INT_MAX;
  int normalInt = 42;
  int overflowInt = largeInt + normalInt;  /* should cause overflow */

  /* if compiling with -ftrapv, we shouldn't get here */
  return 0;
}
```

http://stackoverflow.com/questions/5005379/c-avoiding-overflows-when-working-with-big-numbers

STATIC ANALYSIS TOOLS

Both free and commercial tools

- Commercial tools
  - PC-Lint (Gimpel Software)
  - Klocwork Insight (Klocwork)
  - Coverity (now under HP)
  - Microsoft PREfast (included in Visual Studio)
- Free tools
  - Rough Auditing Tool for Security (RATS) http://code.google.com/p/rough-auditing-tool-for-security/
  - **CppCheck** http://cppcheck.sourceforge.net/
  - Flawfinder http://www.dwheeler.com/flawfinder/
  - Splint http://www.splint.org/
  - **FindBugs** http://findbugs.sourceforge.net (for Java programs)
  - Doxygen's call graphs from source http://www.stack.nl/~dimitri/doxygen/
  - ...

Cppcheck

- A tool for static C/C++ code analysis
  - Open-source freeware, http://cppcheck.sourceforge.net/
  - Online demo http://cppcheck.sourceforge.net/demo/
- Last version 1.80 (2017-07-29)
- Used to find bugs in open-source projects (Linux kernel...)
- Command line & GUI version
- Standalone version, plugin into IDEs, version control...
  - Code::Blocks, Codelite, Eclipse, Jenkins...
  - Tortoise SVN, Visual Studio …
- Cross platform (Windows, Linux)
  - `sudo apt-get install cppcheck`

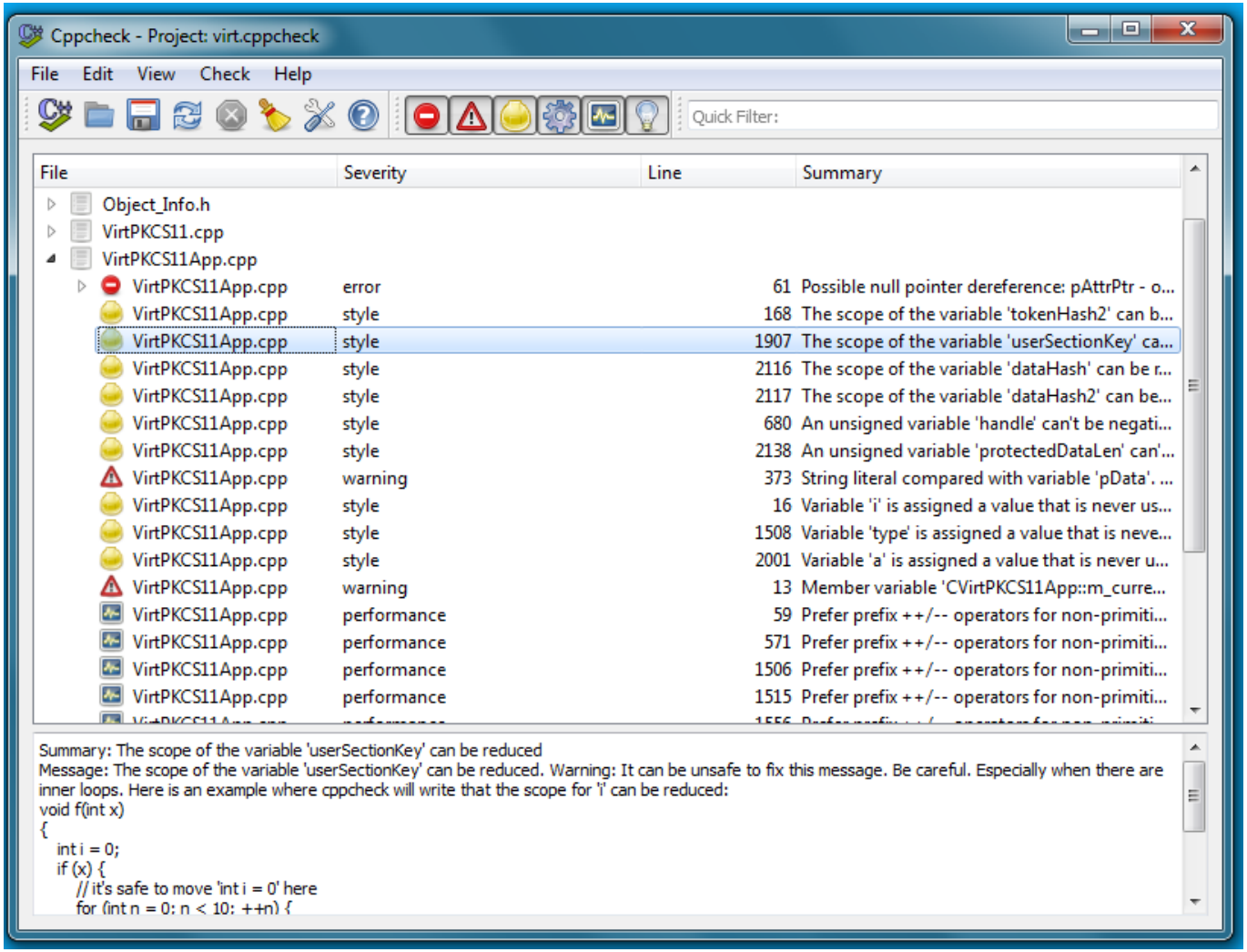
Cppcheck – what is checked?

- Bound checking for array overruns
- Suspicious patterns for class
- Exceptions safety
- Memory leaks
- Obsolete functions
- sizeof() related problems
- String format problems...
- See full list http://sourceforge.net/apps/mediawiki/cppcheck/index.php?title=Main_Page#Checks

Cppcheck – categories of problems

- error – when bugs are found
- warning - suggestions about defensive programming to prevent bugs
- style - stylistic issues related to code cleanup (unused functions, redundant code, constness...)
- performance - suggestions for making the code faster.
- portability - portability warnings. 64-bit portability. code might work different on different compilers. etc.
- information - Informational messages about checking problems

Cppcheck


Cppcheck - Project: virt.cppcheck
File Edit View Check Help
Quick Filter:
File Severity Line Summary
Object_Info.h
VirtPKCS11.cpp
VirtPKCS11App.cpp
VirtPKCS11App.cpp error 61 Possible null pointer dereference: pAttrPtr - o...
VirtPKCS11App.cpp style 168 The scope of the variable 'tokenHash2' can b...
VirtPKCS11App.cpp style 1907 The scope of the variable 'userSectionKey' ca...
VirtPKCS11App.cpp style 2116 The scope of the variable 'dataHash' can be r...
VirtPKCS11App.cpp style 2117 The scope of the variable 'dataHash2' can be...
VirtPKCS11App.cpp style 680 An unsigned variable 'handle' can't be negati...
VirtPKCS11App.cpp style 2138 An unsigned variable 'protectedDataLen' can'...
VirtPKCS11App.cpp warning 373 String literal compared with variable 'pData'. ...
VirtPKCS11App.cpp style 16 Variable 'i' is assigned a value that is never us...
VirtPKCS11App.cpp style 1508 Variable 'type' is assigned a value that is neve...
VirtPKCS11App.cpp style 2001 Variable 'a' is assigned a value that is never u...
VirtPKCS11App.cpp warning 13 Member variable 'CVirtPKCS11App::m_curre...
VirtPKCS11App.cpp performance 59 Prefer prefix ++/-- operators for non-primiti...
VirtPKCS11App.cpp performance 571 Prefer prefix ++/-- operators for non-primiti...
VirtPKCS11App.cpp performance 1506 Prefer prefix ++/-- operators for non-primiti...
VirtPKCS11App.cpp performance 1515 Prefer prefix ++/-- operators for non-primiti...
Summary: The scope of the variable 'userSectionKey' can be reduced
Message: The scope of the variable 'userSectionKey' can be reduced. Warning: It can be unsafe to fix this message. Be careful. Especially when there are inner loops. Here is an example where cppcheck will write that the scope for 'i' can be reduced:
void f(int x)
{
int i = 0;
if (x) {
// it's safe to move 'int i = 0' here
for (int n = 0; n < 10; ++n) {

Cppcheck – simple custom rules

- User can write own regular expression-based rules
  - Perl Compatible Regular Expressions www.pcre.org
  - limited only to simpler analysis
  - executed over *simplified* code (code after preprocessing)
    - http://sourceforge.net/projects/cppcheck/files/Articles/writing-rules-2.pdf
- Regular expression can be supplied on command line
  - `cppcheck.exe --rule=".+" file.cpp`
    - match and print any code, used to obtain simplified code
  - `cppcheck.exe --rule="pass[word]*" file.cpp`
    - match any occurrence of pass or password or passwordword...
- Or via XML file (for stable repeatedly used rules)

Cppcheck – simple custom rules (XML)

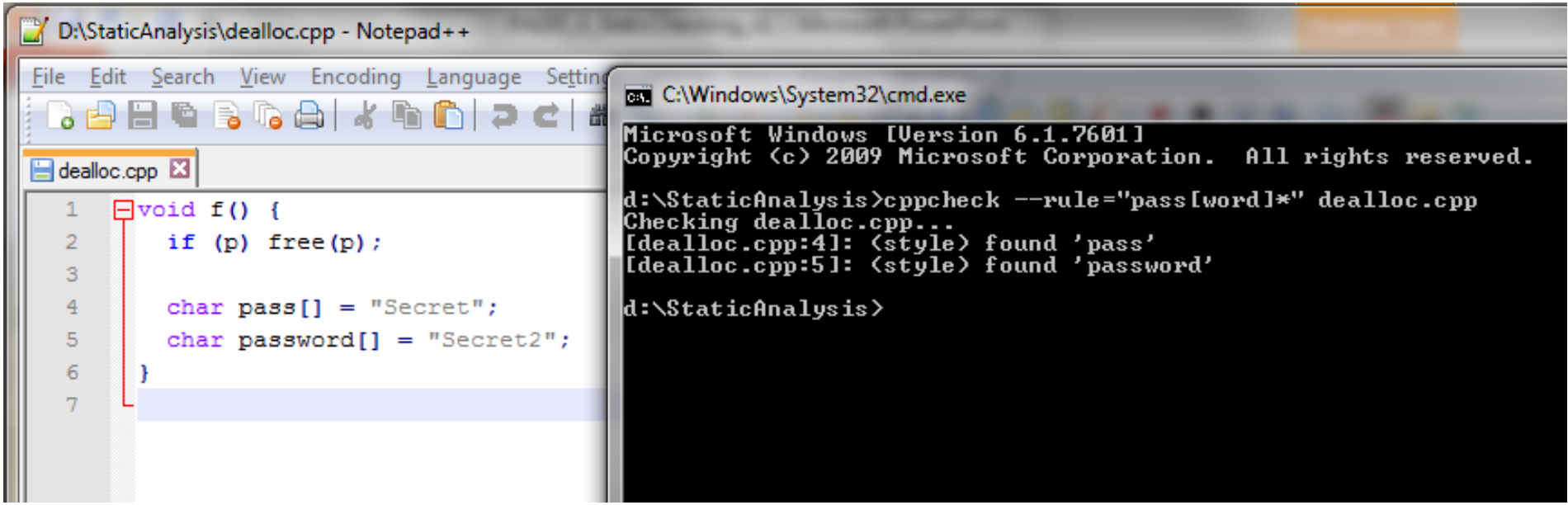
- XML file with regular expression and information
  - pattern to search for
  - information displayed on match

```
<?xml version="1.0"?>
<rule>
 <tokenlist>LIST</tokenlist>
 <pattern>PATTERN</pattern>
 <message>
  <id>ID</id>
  <severity>SEVERITY</severity>
  <summary>SUMMARY</summary>
 </message>
</rule>
```

```
<?xml version="1.0"?>
<rule version="1">
<pattern>if \( p \) { free \( p \) ; }</pattern>
<message>
<id>redundantCondition</id>
<severity>style</severity>
<summary>Redundant condition. It is valid
  to free a NULL pointer.
</summary>
</message>
</rule>
```

Example taken from http://sourceforge.net/projects/cppcheck/files/Articles/writing-rules-1.pdf/download

`cppcheck.exe` --rule="pass[word]*" file.cpp



- `cppcheck.exe` --rule="if \(p \) { free \(p \) ; }" file.cpp
  - will match only pointer with name 'p'

Cppcheck – complex custom rules

- Based on execution of user-supplied C++ code
  - possible more complex analysis

1. Use `cppcheck.exe` --debug file.cpp
   - outputs simplified code including Cppcheck's internal variable unique ID
2. Write C++ code fragment performing analysis
3. Recompile Cppcheck with new rule and execute

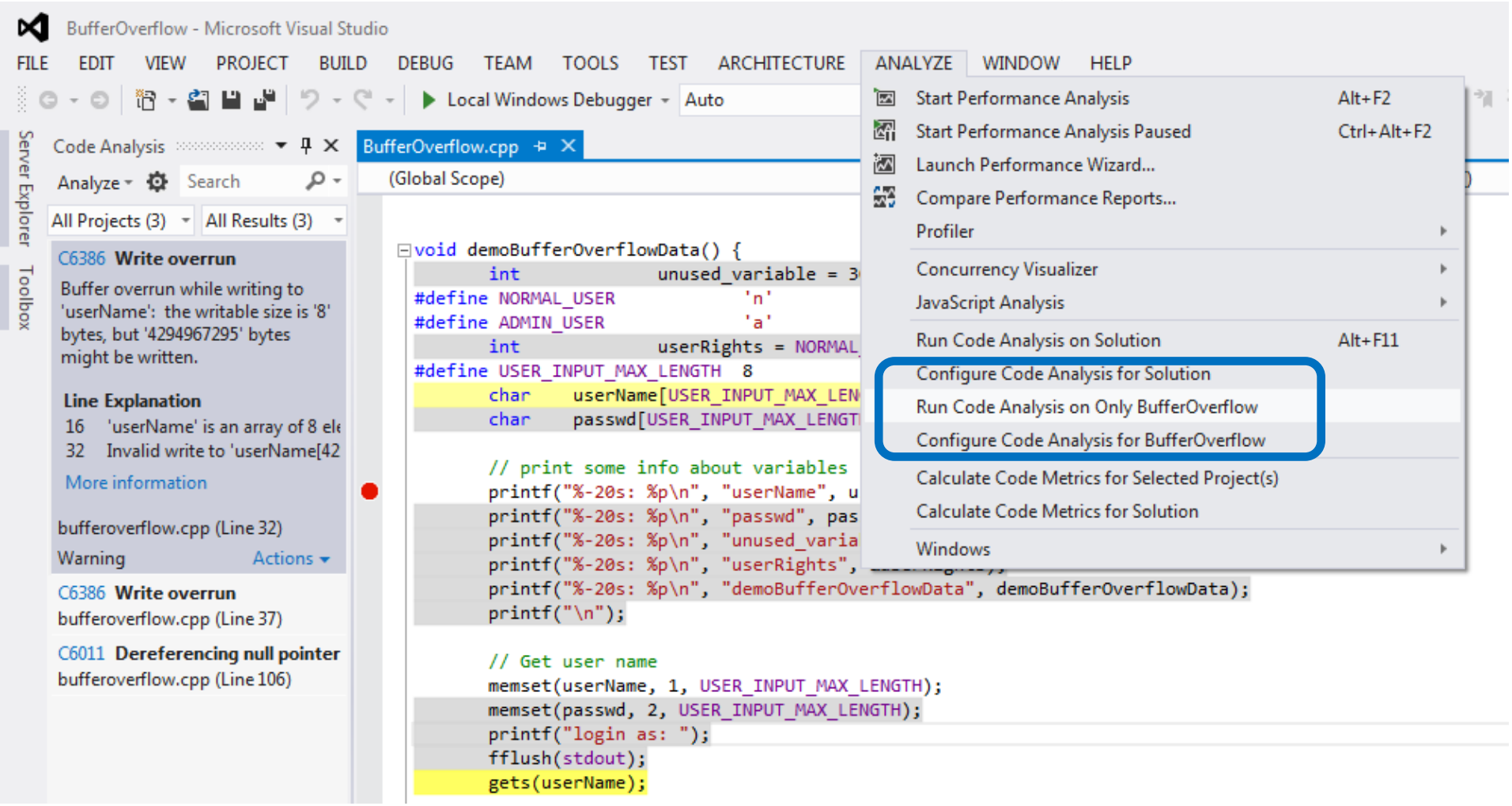
- Read more details (writing-rules-2 & writing-rules-3)
  - http://sourceforge.net/projects/cppcheck/files/Articles/

```
void CheckOther::dealloc() {
  // Loop through all tokens
  for (const Token *tok = _tokenizer->tokens(); tok; tok = tok->next()) {
    // Is there a condition and a deallocation?
    if (Token::Match(tok, "if ( %var% ) { free ( %var% ) ; }")) {
      // Get variable name used in condition:
      const std::string varname1 = tok->strAt(2);
      // Get variable name used in deallocation:
      const std::string varname2 = tok->strAt(7);
      // Is the same variable used?
      if (varname1 == varname2) {
        // report warning
        deallocWarning(tok);
      }
    }
  }
}
// Report warning
void CheckOther::deallocWarning() {
  reportError(tok, // location
  Severity::warning, // severity
  "dealloc", // id
  "Redundant condition"); // message
}
```

pattern to match %var% will match any variable

reporting error in standard format

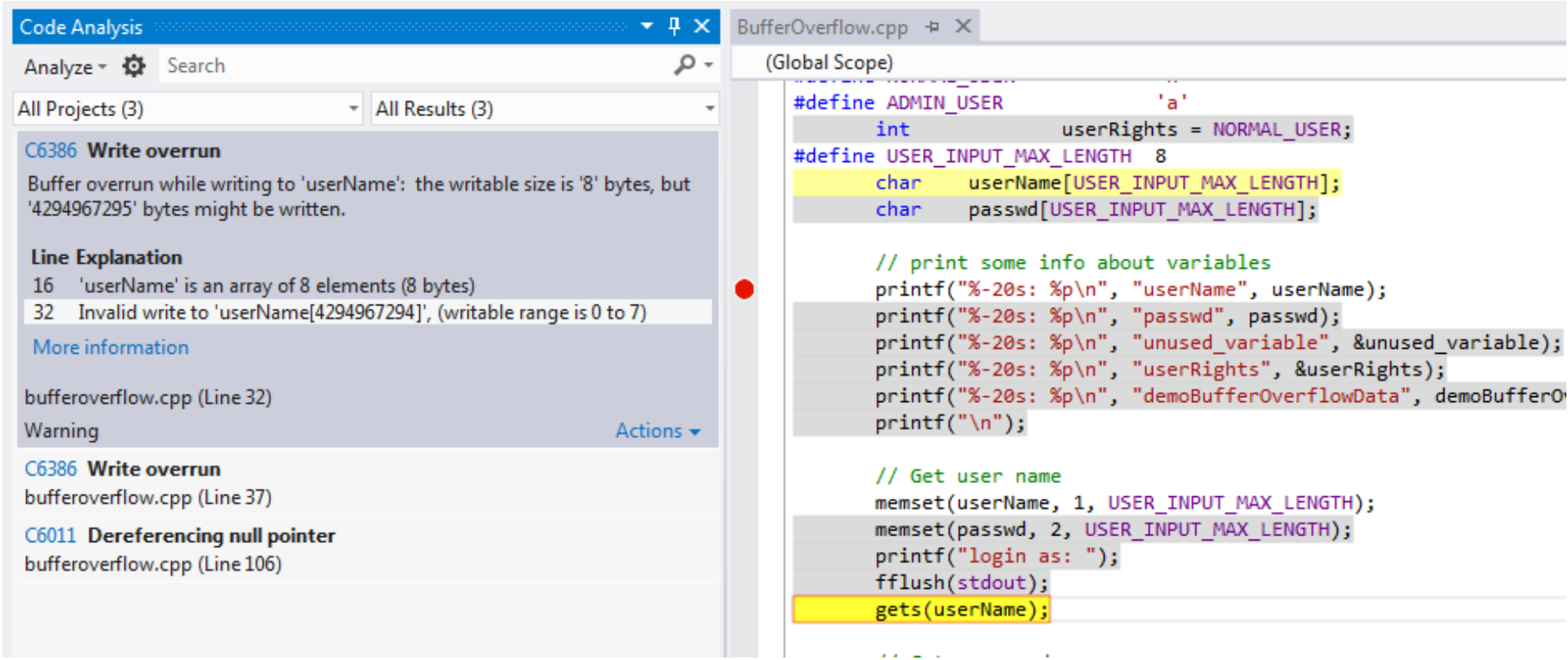
PREfast - Microsoft static analysis tool



PREfast - Microsoft static analysis tool

- Visual Studio Ultimate and Premium Editions
- Documentation for PREfast
  - http://msdn.microsoft.com/en-us/library/windows/hardware/gg487351.aspx
- PREfast tutorial
  - http://www.codeproject.com/Articles/167588/Using-PREfast-for-Static-Code-Analysis
- Can be enabled on every build
  - not enabled by default, time consuming
- Can be extended by source code annotation (SAL)
  - (lecture 8)

PREfast – example bufferOverflow

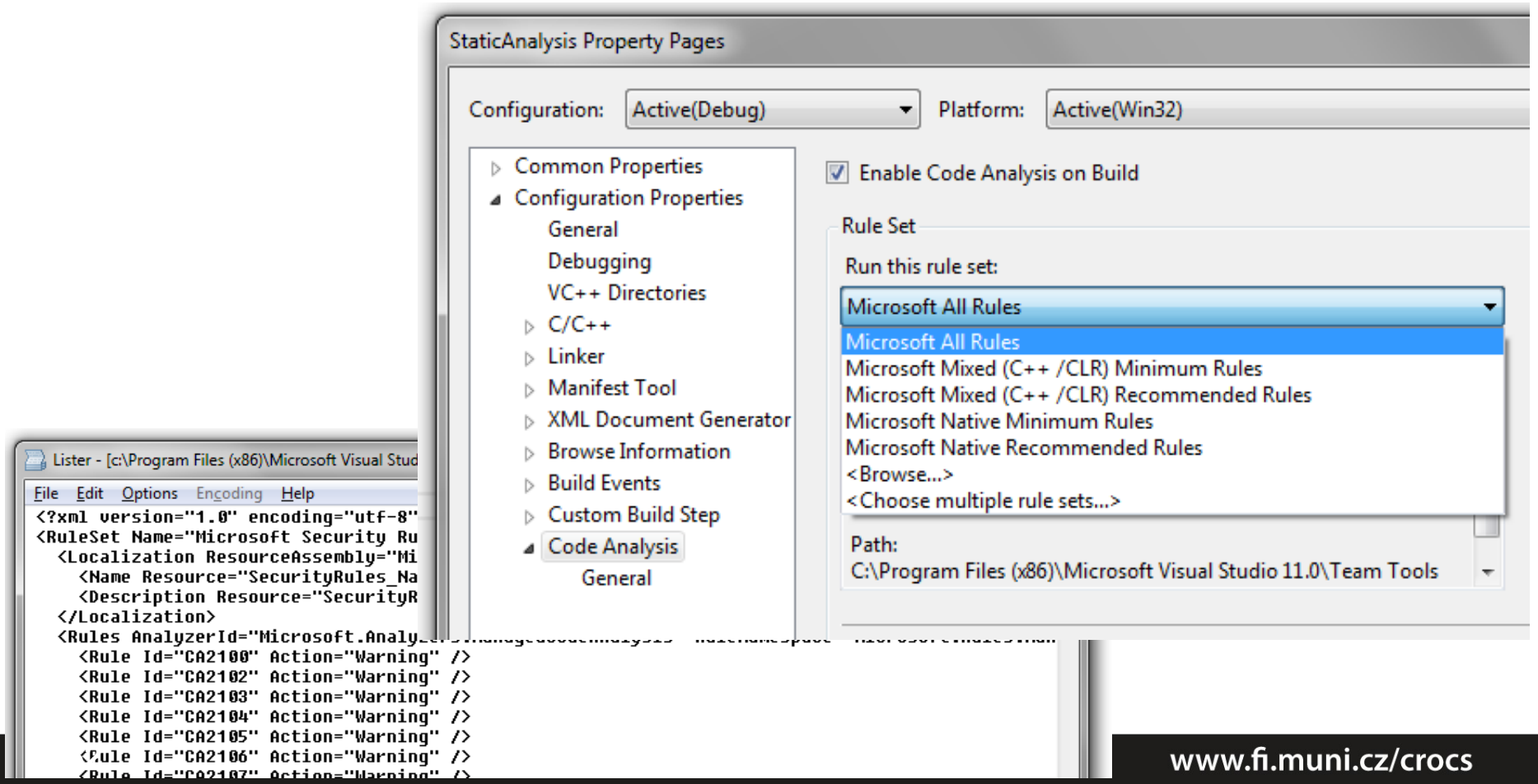


PREfast – what can be detected

- Potential buffer overflows
- Memory leaks, uninitialized variables
- Excessive stack usage
- Resources – release of locks...
- Incorrect usage of selected functions
- List of all code analysis warnings
  http://msdn.microsoft.com/en-us/library/a5b9aa09.aspx

PREfast settings (VS 2015)

- http://msdn.microsoft.com/en-us/library/ms182025.aspx



PREfast & MSVC /analyze

- Enables code analysis and control options
  - http://msdn.microsoft.com/en-us/library/ms173498.aspx
- Some analysis rules work only for managed code (C#, VB...)
- Available rule sets
  - http://msdn.microsoft.com/en-us/library/dd264925%28v=vs.120%29.aspx
- Possibility to write custom rules
  - http://msdn.microsoft.com/en-us/library/dd380660%28v=vs.120%29.aspx

Coverity (free for open-source)

- Commercial static & dynamic analyzer
- Free for C/C++ & Java open-source projects
- https://scan.coverity.com/
- Process
  - Register at scan.coverity.com (GitHub account possible)
  - Download Coverity build tool for your platform
    - Quality and Security Advisor
  - Build your project with cov-build
    - cov-build --dir cov-int <build command>
  - Zip and submit build for analysis (works on binary, not source
- Can be integrated with Travis CI (continuous integration)
  - https://scan.coverity.com/travis_ci

petrs-JCAlgTest | Help | Guided Tour | Return to Dashboard | petr@svenda.com | Enter CID(s)

Issues: By Snapshot | Outstanding Defects | Filters: Issue Kind, Classification

CID	Type	Impact	Status	First Detected	Owner	Classification	Sev
44903	Dereference null return	Medium	New	08/12/14	Unassigned	Unclassified	
44892	Dereference null return	Medium	New	08/12/14	Unassigned	Unclassified	
44891	Dereference null return	Medium	New	08/12/14	Unassigned	Unclassified	

1 of 19 issues selected | Page 1 of 1

44903 Dereference null return value

If the function actually returns a null value, a NullPointerException will be thrown.

In algtestjclient.AlgTestJClient.main(java.lang.String[]): Return value of function which returns null is dereferenced without checking (CWE-476)

Triage

Classification: Bug
Severity: Moderate
Action: Fix Required
Ext. Reference: Type attribute text
Owner: PetrS

Enter comments (See the History section below for previous comments)

Apply

AlgTestJClient.java

```
System.out.println("\n\nSTRONG WARNING: There is possibility tha
System.out.println("\n\nWARNING: Your card should be free from o
System.out.println("Type 1 for yes, 0 for no: ");
```

CID 44893: Resource leak on an exceptional path (RESOURCE_LEAK) [select issue]

42. returned_null: br.readLine() returns null.

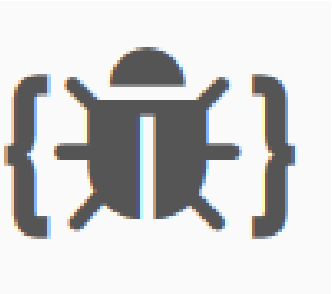
CID 44903 (#4 of 4): Dereference null return value (NULL_RETURNS)

43. dereference: Dereferencing a pointer that might be null br.readLine() when calling decode.

```
answ = Integer.decode(br.readLine());
}
i
```

FindBugs

- Static analysis of Java programs
- Extended coverage for OWASP Top 10 and CWE
- Current version 3.0.1 (2015-03-06)
  - http://findbugs.sourceforge.net/
  - Command-line, GUI, plugins into variety of tools
  - Support for custom rules
- FindSecurityBugs 1.7.1. (2017-08-07)
  - Additional detection rules for FindBugs
  - https://h3xstream.github.io/find-sec-bugs/bugs.htm



How many false positives are too many?

- *"Because its analysis is sometimes imprecise, FindBugs can report false warnings, which are warnings that do not indicate real errors. In practice, the rate of false warnings reported by FindBugs is less than 50%."*

FindBugs™ Fact Sheet

STATIC ANALYSIS IS NOT PANACEA

Cppcheck --enable=all

```
d:\StaticAnalysis>cppcheck --enable=all bufferOverflow.cpp
Checking bufferOverflow.cpp...
[bufferOverflow.cpp:26]: (style) Obsolete function 'gets' called. It is recommended to use
                         the function 'fgets' instead.
[bufferOverflow.cpp:31]: (style) Obsolete function 'gets' called. It is recommended to use
                         the function 'fgets' instead.
```

MSVC /W4

```
1>  BufferOverflow.cpp
1>bufferoverflow.cpp(32): warning C4996: 'gets': This function or variable may be unsafe.
          Consider using gets_s instead. To disable deprecation, use _CRT_SECURE_NO_WARNINGS.
1>  c:\program files (x86)\microsoft visual studio 11.0\vc\include\stdio.h(261) : see declaration of 'gets'
1>bufferoverflow.cpp(37): warning C4996: 'gets': This function or variable may be unsafe.
          Consider using gets_s instead. To disable deprecation, use _CRT_SECURE_NO_WARNINGS.
1>        c:\program files (x86)\microsoft visual studio 11.0\vc\include\stdio.h(261) : see declaration of 'gets'
1>bufferoverflow.cpp(78): warning C4996: 'strncpy': This function or variable may be unsafe.
          Consider using strncpy_s instead. To disable deprecation, use _CRT_SECURE_NO_WARNINGS.
1>  c:\program files (x86)\microsoft visual studio 11.0\vc\include\string.h(191) : see declaration of 'strncpy'
1>bufferoverflow.cpp(81): warning C4996: 'sprintf': This function or variable may be unsafe.
Consider using sprintf_s instead. To disable deprecation, use _CRT_SECURE_NO_WARNINGS.
1>  c:\program files (x86)\microsoft visual studio 11.0\vc\include\stdio.h(357) : see declaration of 'sprintf'
```

```
fflush(stdout);
```

MSVC /analyze (PREfast)

```
1>  BufferOverflow.cpp
bufferoverflow.cpp(32): warning : C6386: Buffer overrun while writing to 'userName':
          the writable size is '8' bytes, but '4294967295' bytes might be written.
bufferoverflow.cpp(37): warning : C6386: Buffer overrun while writing to 'passwd':
          the writable size is '8' bytes, but '4294967295' bytes might be written.
```

From 2. lecture

Type overflow – example with dynalloc

```
typedef struct _some_structure {
        float   someData[1000];
} some_structure;

void demoDataTypeOverflow(int totalItemsCount, some_structure* pItem,
                          int itemPosition) {
 // See http://blogs.msdn.com/oldnewthing/archive/2004/01/29/64389.aspx
 some_structure* data_copy = NULL;
 int bytesToAllocation = totalItemsCount * sizeof(some_structure);
 printf("Bytes to alloca
 data_copy = (some_struc
 if (itemPosition >= 0 &
    memcpy(&(data_copy[i
 }
 else {
    printf("Out of bound
    return;
 }
 free(data_copy);
}
```

Cppcheck --enable=all

```
d:\StaticAnalysis>cppcheck --enable=all typeOverflow.cpp
Checking typeOverflow.cpp...
[typeOverflow.cpp:17]: (error) Memory leak: data_copy
```

MSVC /W4

```
1>  typeOverflow.cpp  nothing ☺
```

MSVC /analyze (PREfast)

```
1>  typeOverflow.cpp
bufferoverflow.cpp(13): warning : C6011:
Dereferencing NULL pointer 'data_copy'.
```

Test suites – vulnerable code, benchmark

- SAMATE Juliet Test Suite
  - huge test suite which contains at least 45000 C/C++ test cases
  - http://samate.nist.gov/SRD/testsuite.php
- Static analysis test suite for C programs
  - http://mathind.csd.auth.gr/static_analysis_test_suite/
- Suitable for testing new methods, but for comparison of existing commercial products
  - Public suites, products already optimized for it

SUMMARY

Summary

- Static analysis is VERY important tool for writing secure software
  - significant portion of analysis done already by compiler (errors, warning)
- Multiple tools exist (both free and commercial)
  - predefined set of rules, custom rules can be written
  - Differ in capability and target audience
- Static analysis cannot find all problems
  - problem of false positives/negatives
  - no substitution for extensive testing and defense programming

Mandatory reading

- Coverity open source reports 2013/2014
  - Report of analysis for open-source projects
  - https://na-sjf.marketo.com/rs/appsec/images/2013-Coverity-Scan-Report.pdf
  - http://go.coverity.com/rs/157-LQW-289/images/2014-Coverity-Scan-Report.pdf
- How open-source and closed-source compare wrt number of defects? How os/cs address OWASP Top 10?
- What are typical issues in C/C++ code?
- …