Software security
specification and verification

Erik Poll

Security of Systems (SoS) group

Radboud University Nijmegen

Software (in)security
specification and verification/detection

Erik Poll

Security of Systems (SoS) group

Radboud University Nijmegen

How I got interested in software security

- Tool-supported formal specification and verification of Java software
- JavaCard programs for smartcards ideal target for verification

- But... what are the security properties to verify ??
- Physical attacks on smartcards better understood than "logical" attacks on software
- Properties to verify: absence of runtime exceptions or integer overflow, preservation of invariants, ... rather than complete functional specs

Software security

- Vast majority of security problems are caused by software

- Software security excludes
  - crypto, but not implementation of crypto
  - social engineering attacks
  - hardware security, eg. tamper-resistance

Getting software secure is difficult!

Eg, from www.cert.org/advisories for (Open)SSH

CA-2001-35 Recent Activity Against Secure Shell Daemons (Dec 13) There are multiple vulnerabilities in several implementations of SSH. ...

CA-2002-18 OpenSSH Vulnerability in challenge-response handling (Jun 26) There are vulnerabilities in challenge response handling code ...

CA-2002-23 Multiple Vulnerabilities in OpenSSH (July 30) There are four remotely exploitable buffer overflows in ...

CA-2002-24 Trojan Horse OpenSSH Distribution (Aug 1) Some copies of the source code of OpenSSH package contain a Trojan horse. ....

CA-2002-36 Multiple Vulnerabilities in SSH Implementations (Dec 16) Multiple vendors' implementations of SSH contain vulnerabilities ...

CA-2003-24: Buffer Management Vulnerability in OpenSSH (Sept 16) There is a remotely exploitable buffer overflow in versions of OpenSSH prior to 3.7

Will there be more ?

Note that crypto is not the solution to our problems.

Some reasons why security is difficult

- Security concerns are always secondary
  - primary goal of software is to provide some functionality or services; managing risks this introduces is a derived/secondary concern.
- Saying what is not secure is easier than saying what is secure
- Security problems can go unnoticed during normal use and testing
- Security may conflict with functionality and convenience
  - for users, but also for programmers and sys-admins

Example: programmer convenience vs security

- generally accepted Java coding standard:

  "prefer protected to private"

  - motivation: allows useful subclassing

- but Java security guideline:

  "avoid using protected"

  - motivation: protected really means unprotected

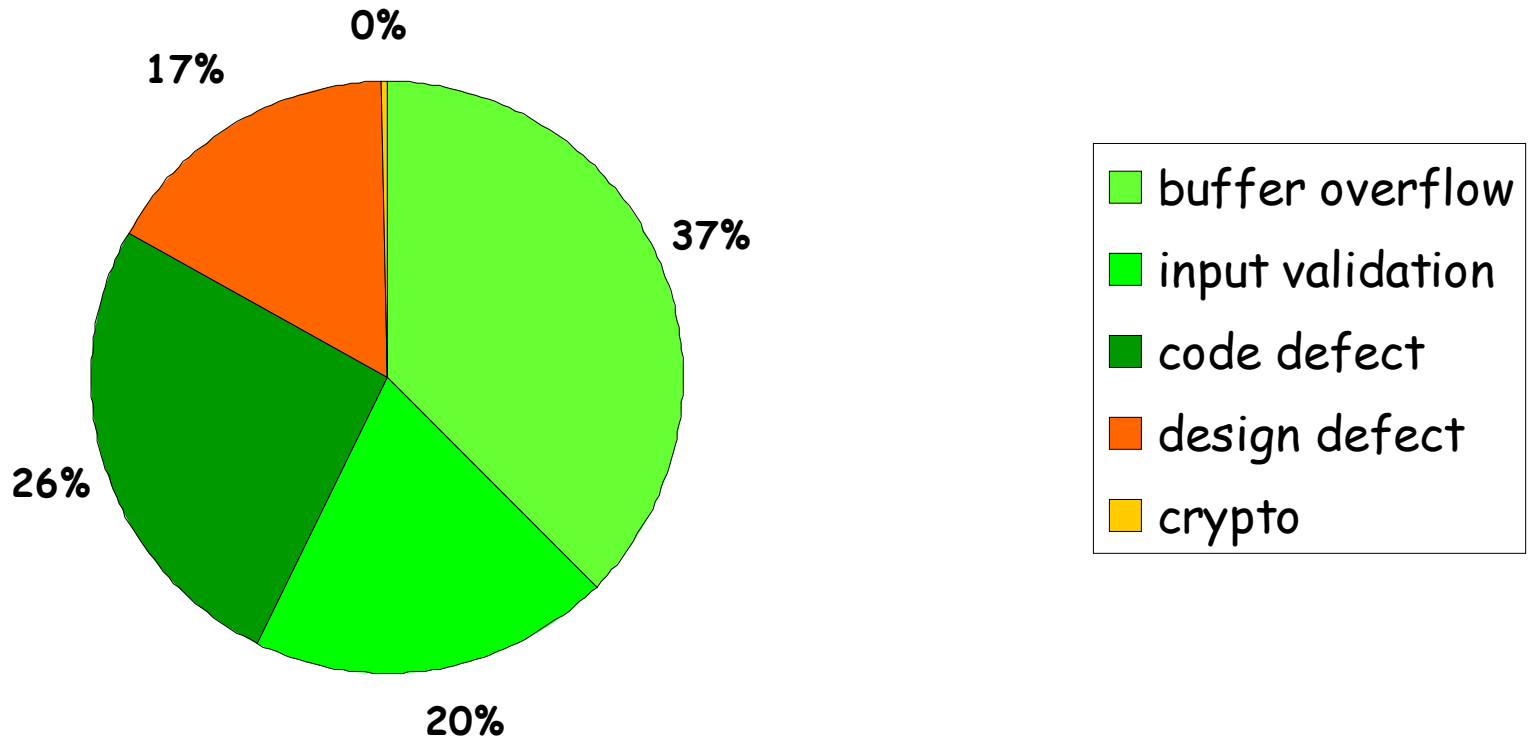
Security in software development life cycle

- Security is a concern throughout SDLC
- Ideally, catch problems as early as possible
- Still, many software vulnerabilities are introduced in the coding phase.

  Namely coding bugs
  - eg buffer overflows

  as opposed to architectural flaws
  - eg use of RPC under Windows

Typical software vulnerabilities



Security bugs found in Microsoft bug fix month (2002)

Example: famous Java security bug in JDK1.1

```
package java.lang;

public class Class {
 private Object[] signers;
 ...
 public Object[] getSigners() { return signers; }
 ...
```

This bug won't be caught by typical functional specs, or detected by typical tests

The bad news

- There are many things that can go wrong in coding phase:
  - long lists of dont's
- These may involve interaction of features, and can be hard to spot (or test)
- Programmers often not aware of them

Eg. one major creditcard company lists 214 requirements for JavaCard smartcard code, to be checked in source code reviews.

The good news

- The same things tend to go wrong
- Largely independent of application, but depending on
  - the programming language
    - eg. buffer overflows in C(++)
  - the platform/OS
    - eg. unsafe use of system calls and environment variables
  - the kind of application
    - eg. SQL command injections in webservers

The problem with long checklists of "dont's"

- Are programmers even aware of them ?
  - Educate programmers
- How do we know the list is complete ?
  - Publish & discuss these lists
  - Challenge for scientific research
- How do we check them ?
  - Automate this!

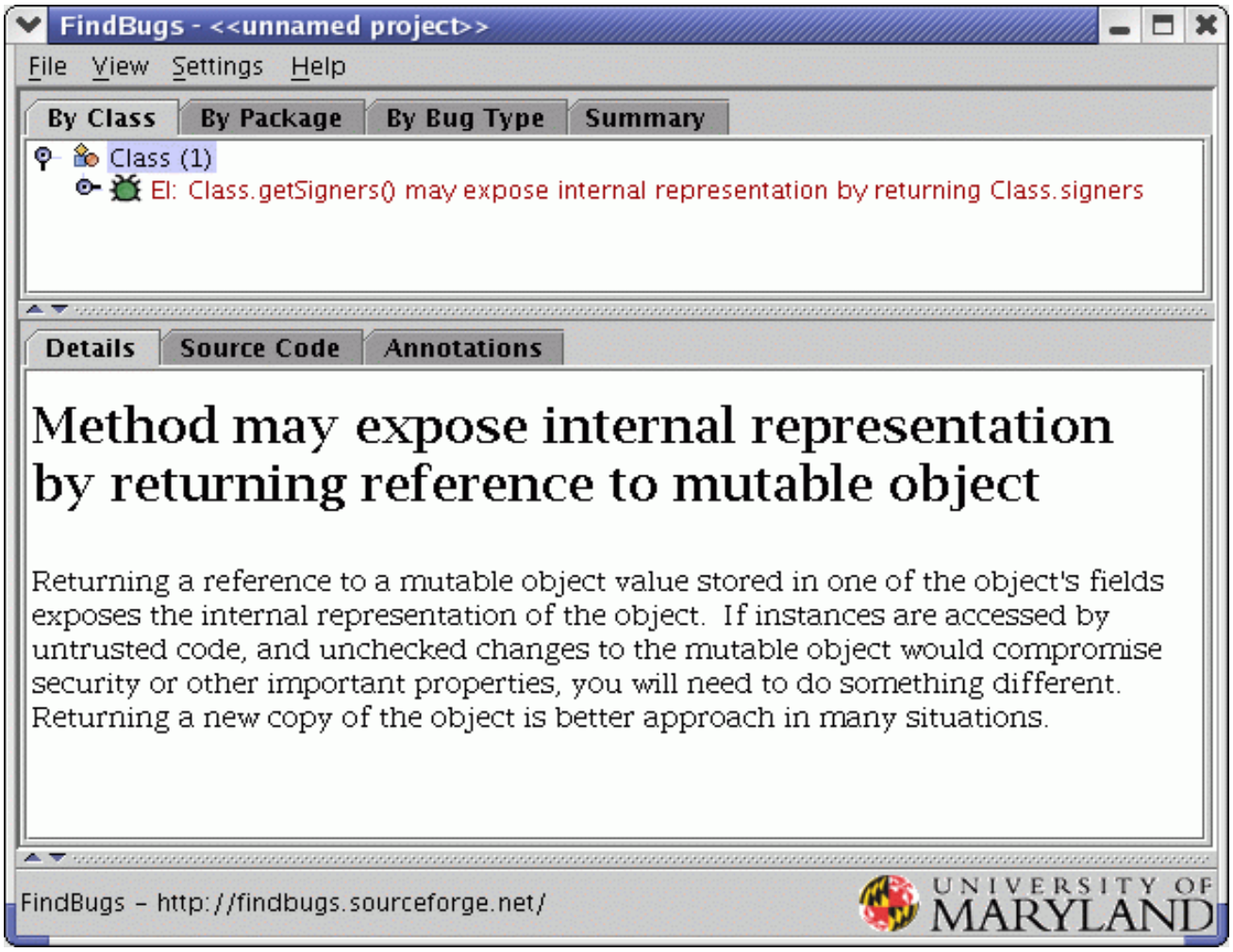
    Using static checkers aka source code analysers

Some (free) source code analysers

- ITS4 (C/C++)
- RATS (C/C++/Perl/PHP)
- Flawfinder (C/C++)
- FindBugs (Java)
- .....

Source code analysis not just for security, but for general software quality

Example: FindBugs source code analyser



- Of course, ideally flaws should be prevented at the language level.
- Eg
  - no buffer overflows in Java or C#
  - tainted mode for input data in Perl
  - escaping meta-characters in PHP

Conclusions – the bad news

- Be aware that security tends to be ignored
- Security is hard to specify
  - long lists of dont's
- Software flaws are main cause of security problems
- Software flaws can be hard to uncover with testing or detect with normal use

Conclusions – some good news

- More standard patterns of security vulnerabilities are widely known
- Improving static checkers can detect such patterns (also thanks to Moore's Law)

- Newer languages and platforms will have fewer vulnerabilities ?