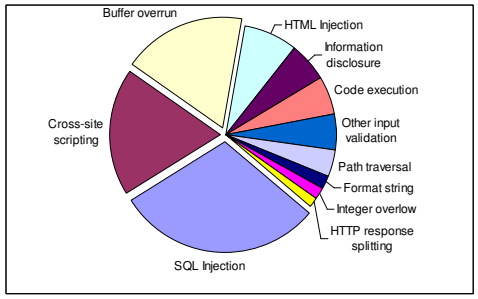
Static and Runtime Solutions for Web Application Vulnerabilities

Benjamin Livshits, Stanford University

Web Application Vulnerabilities on the Rise

Compared to several years ago vulnerabilities like SQL injections and cross-site scripting attacks dominate the charts



A study of 500 vulnerability reports in Nov.—Dec. 2005

Griffin Application Security Project

`http://suif.stanford.edu/~livshits/work/griffin/`

We propose a hybrid static/runtime solution to Web application vulnerabilities. Our focus is on Java J2EE applications

Goes after the most prominent vulnerability types:

- SQL injections
- Cross-site scripting
- Path traversal
- HTTP splitting
- etc.

An extensible definition language PQL is used for specifying vulnerabilities

Static Error Detection

Analyze applications as they are being developed

Advantages:

- Finds vulnerabilities early in development cycle
- Sounds, so finds all vuln. of a particular type
- Can run after every build ensuring continuous security

Described in **Finding Security Vulnerabilities in Java Applications with Static Analysis, Benjamin Livshits and Monica S. Lam,** In *Proceedings of the Usenix Security Symposium*, Baltimore, Maryland, August 2005.

```
query simpleSQLInjection
  returns
     object String param, derived;
  uses
     object HttpServletRequest  req;
     object Connection          con;
     object StringBuffer        temp;
  matches {
     param   = req.getParameter(_);

     temp.append(param);
     derived = temp.toString();

     con.executeQuery(derived);
  }
```

Static analysis is based on a state-of-the-art fully context-sensitive pointer analysis with extensions

Many practical issues needed to be addressed:
- Handle containers without a loss of precision
- Construct the application call graph in the presence of reflective constructs of Java (see "Reflection Analysis for Java", Livshits, Whaley, and Lam, Nov. 2005)

Result summary:
- Analyzed 9 large open-source Web applications in Java
- Thousands of users combined
- 29 vulnerabilities found, most confirmed and fixed

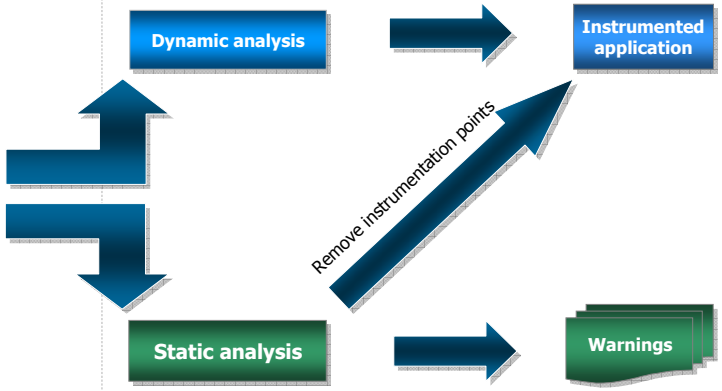
Runtime Prevention & Recovery

Protect existing applications

Advantages:

- Prevents vulnerabilities from doing harm
- Safe mode for Web application execution
- Can quarantine suspicious actions, application continues to run
- No false positives

Described in **Finding Application Errors and Security Flaws Using PQL: a Program Query Language, Michael Martin, Benjamin Livshits, and Monica S. Lam,** Presented at the *20th Annual ACM Conference on Object-Oriented Programming, Systems, Languages, and Applications*, San Diego, California, October 2005.



Runtime analysis works by instrumenting an existing application to look for matches of a specified pattern. A recovery policy can be specified also

Some issues to address:
- Overhead can be high (usually 35-55%)
- Have a static optimization technique that brings the overhead down to several percent

Result summary:
- Detected and prevented exploits in all our experiments
- Unoptimized overhead: 57% average
- Optimized overhead: 14% average
- Static privation removes 82-99% of instr. points