Secure Programming with Static Analysis

Brian Chess

brian@fortify.com

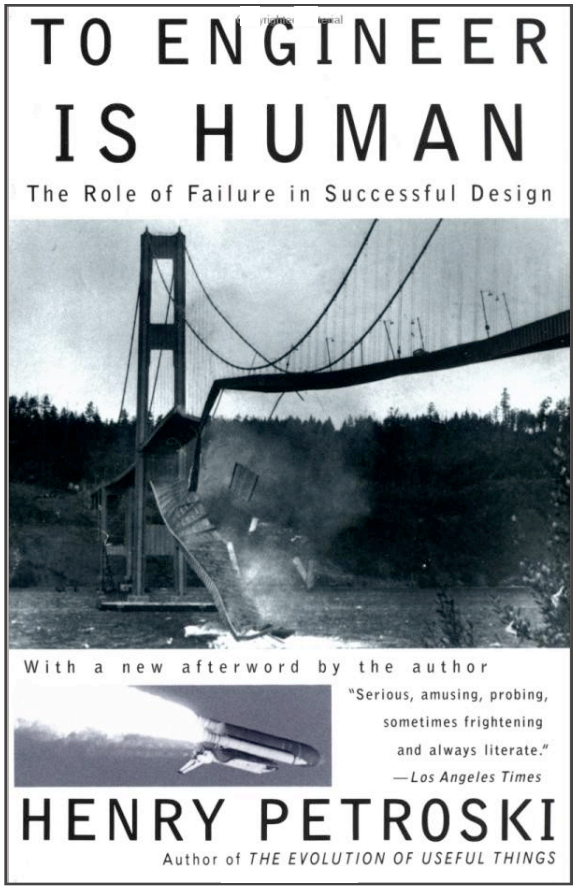

Software Systems that are
• Ubiquitous
• Connected
• Dependable
Complexity
Unforeseen
Consequences

Software Security Today

- The line between secure/insecure is often subtle
  - Many seemingly non-security decisions affect security
- Small problems can hurt a lot
- Smart people make dumb mistakes
  - As a group, programmers tend to make the same security mistakes over and over
- We need non-experts to get security right

Success is foreseeing failure.

– Henry Petroski



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Non-functional Security Failures

Generic Mistakes

- Input validation
- Memory safety (buffer overflow)
- Handling errors and exceptions
- Maintaining privacy

Common Software Varieties

- Web applications
- Network services / SOA
- Privileged programs

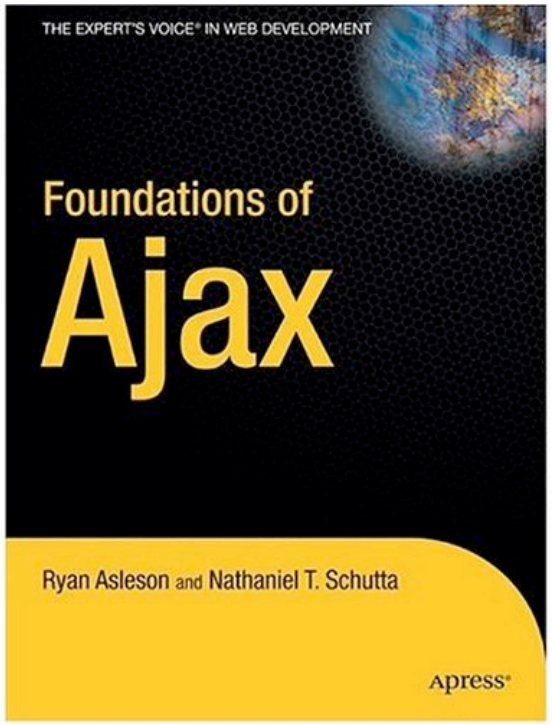
Buffer Overflow

MSDN sample code for function DirSpec:

```
int main(int argc, char *argv[]) {
  ...
  char DirSpec[MAX_PATH + 1];
  printf ("Target dir is %s.\n", argv[1]);
  strncpy (DirSpec, argv[1], strlen(argv[1])+1);
```

Cross-Site Scripting

```
<c:if
   test="${param.sayHello}">
   Hello ${param.name}!
</c:if>
```



"We never intended the code that's in there to actually be production-ready code"

- Ryan Asleson

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Wrong Answers

Try Harder

- Our people are smart and work hard.
- Just tell them to stop making mistakes.

- Not everyone is going to be a security expert.
- Getting security right requires feedback.

Fix It Later

- Code as usual.
- Build a better firewall (app firewall, intrusion detection, etc.)

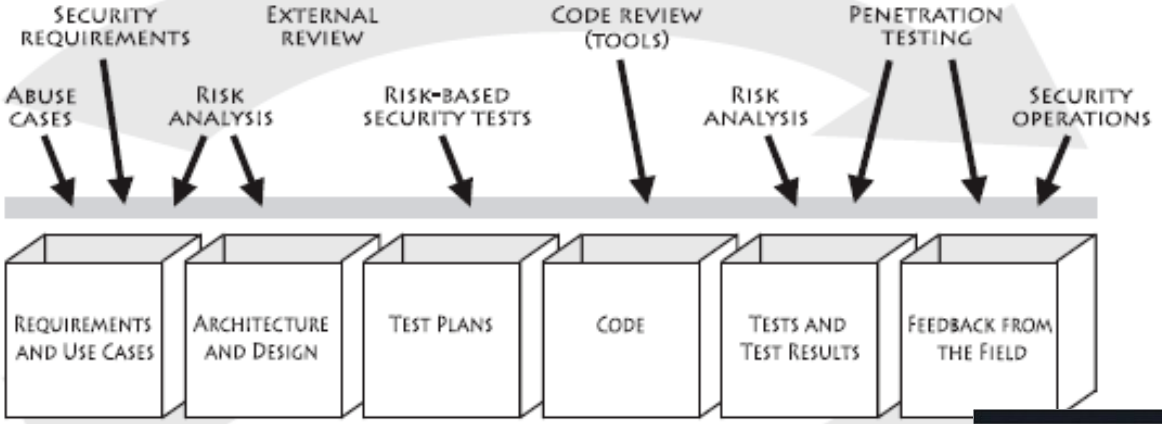
- More walls don't help when the software is meant to communicate.
- Security team can't keep up.

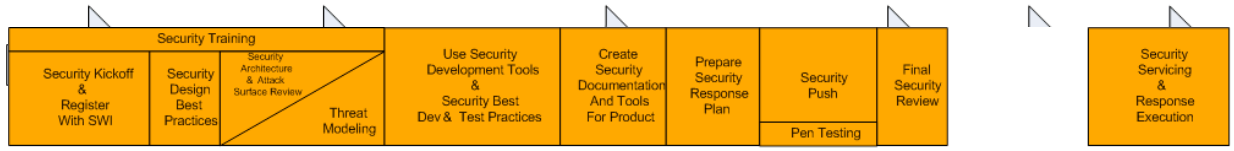
Test Your Way Out

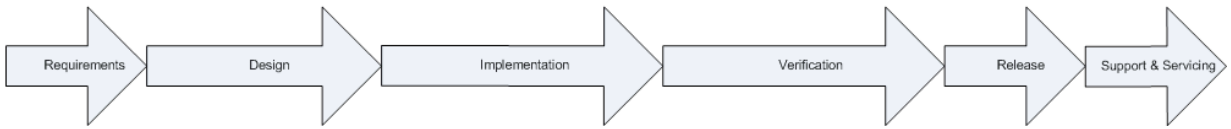
- Do a penetration test on the final version.
- Scramble to patch findings.

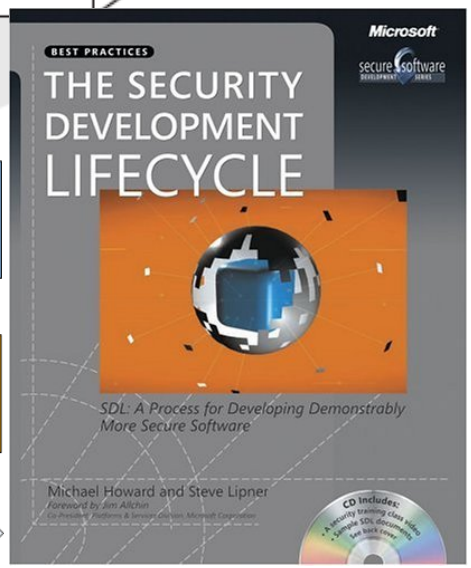
- Pen testing is good for demonstrating the problem.
- Doesn't work for the same reason you can't test quality in.

Security in the Development Lifecycle









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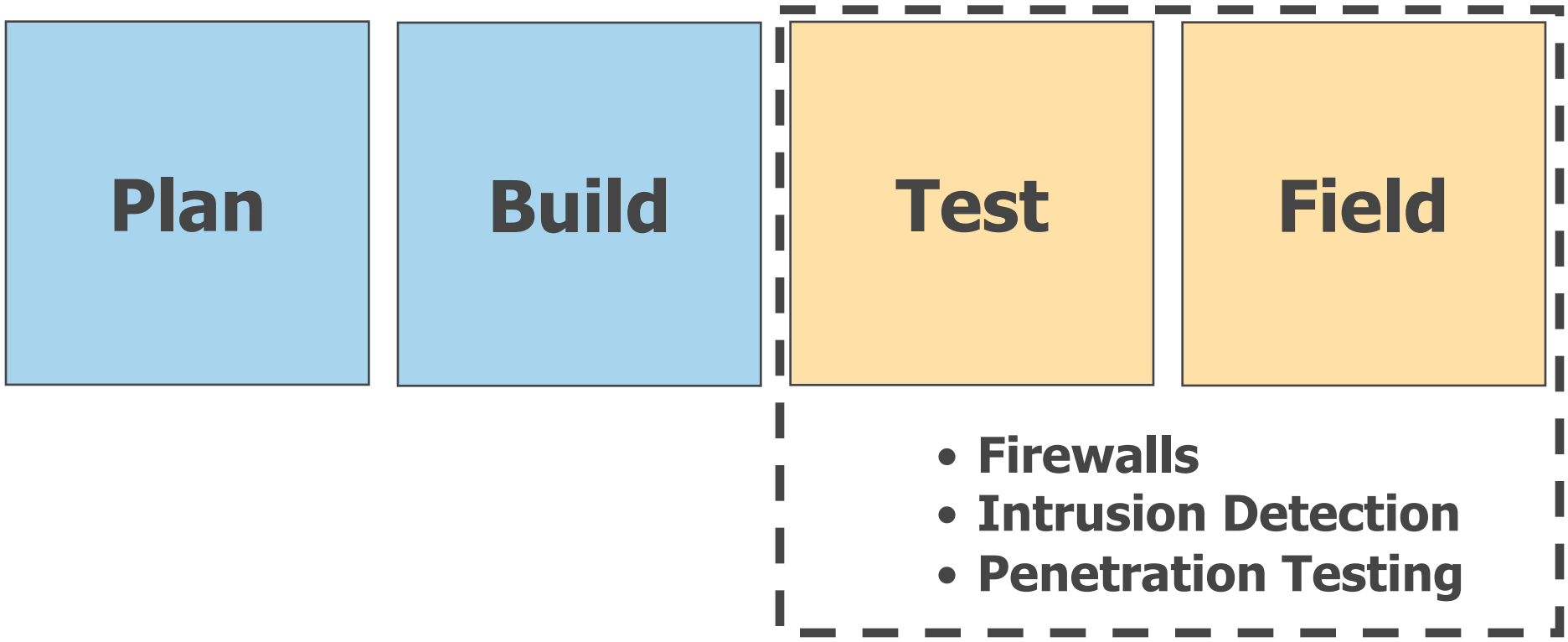
Security in the Development Lifecycle



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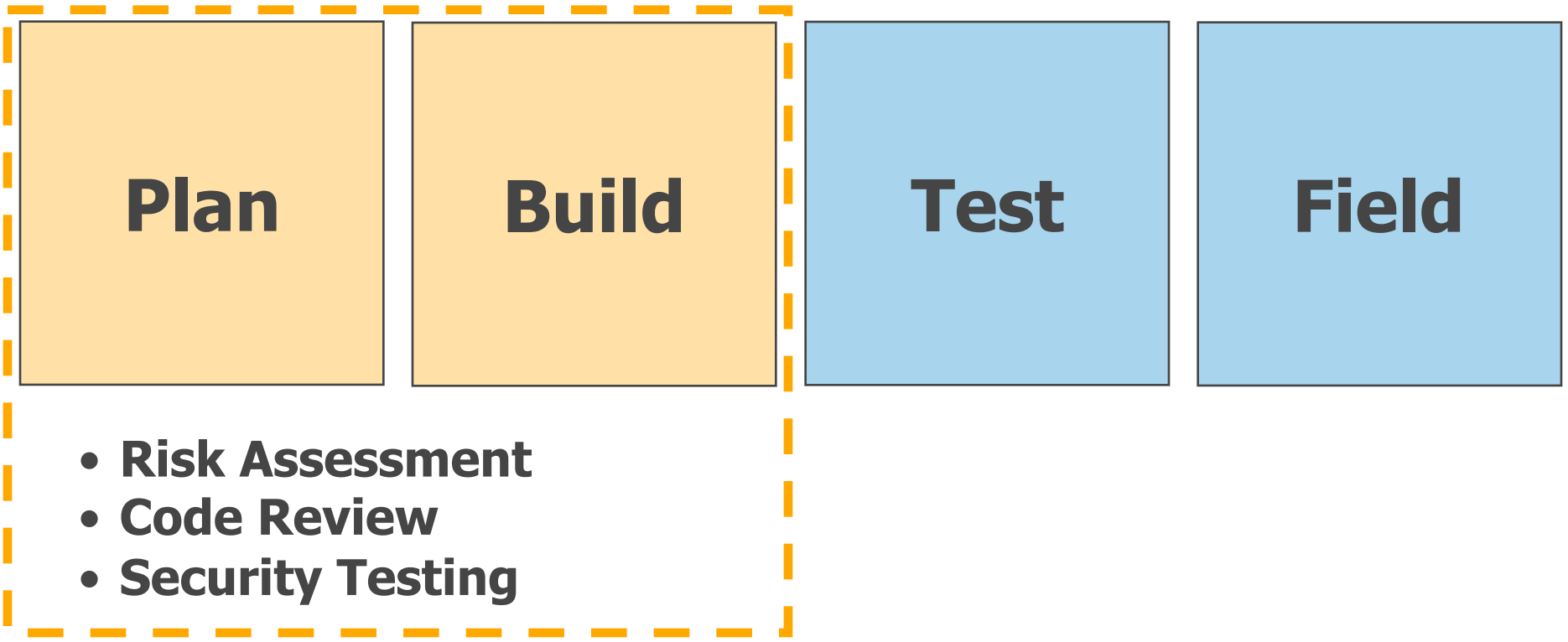

Overview

- Introduction
- Static Analysis: The Big Picture
- Inside a Static Analysis Tool
- Static Analysis in Practice
- What Next?
- Parting Thoughts

Static Analysis: The Big Picture

Static Analysis Defined

- Analyze code without executing it
- Able to contemplate many more possibilities than you could execute with conventional testing
- Doesn't know what your code is supposed to do
- Must be told what to look for

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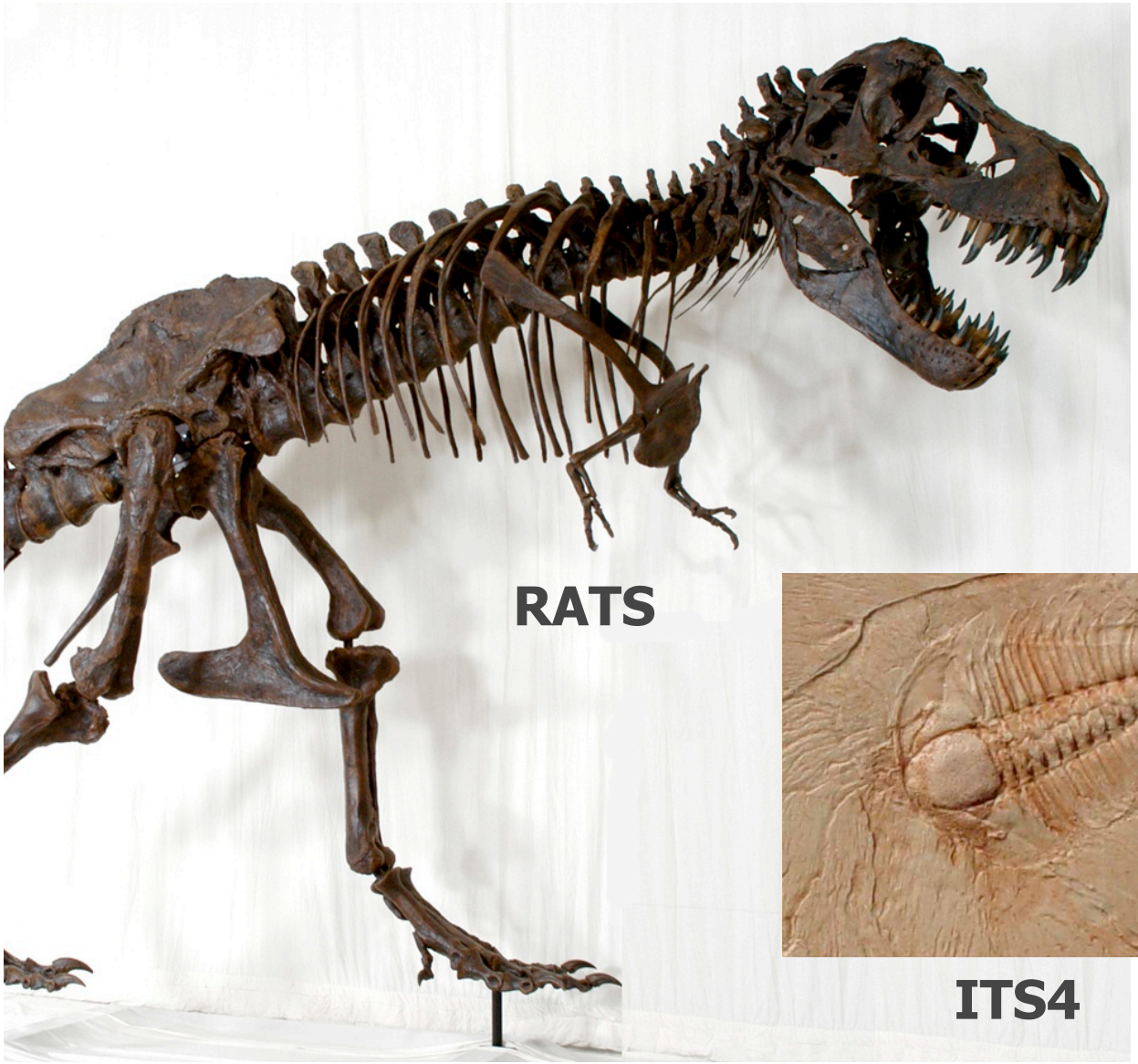
The Many Faces of Static Analysis

- Type checking
- Style checking
- Program understanding
- Program verification / Property checking
- Bug finding
- Security review

Why Static Analysis is Good for Security

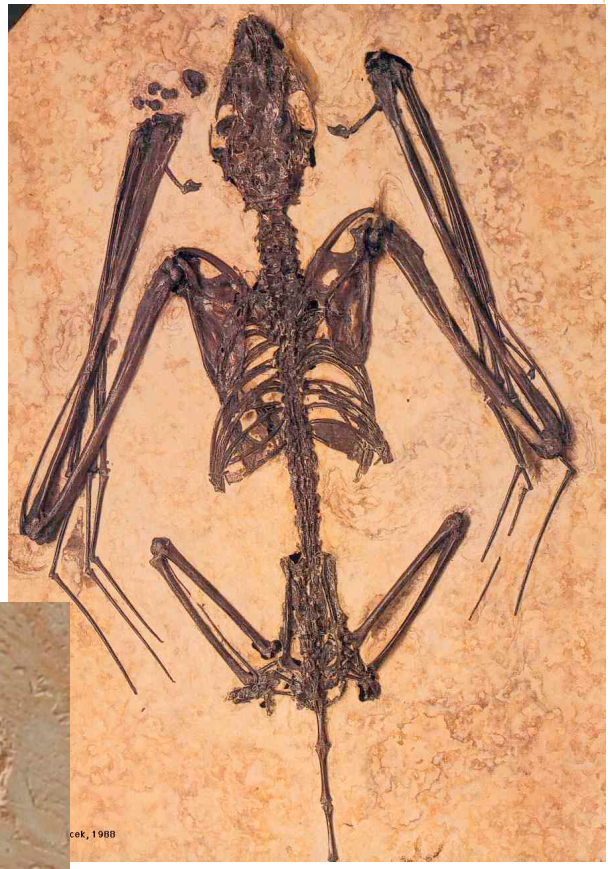
- Fast compared to manual code review
- Fast compared to testing
- Complete, consistent coverage
- Brings security knowledge with it
- Makes review process easier for non-experts

Prehistoric static analysis tools



RATS

ITS4



Flawfinder

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Prehistoric static analysis tools

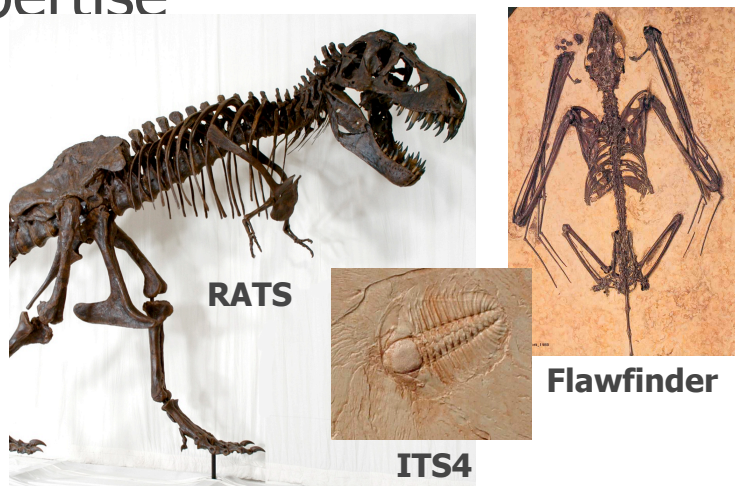
Glorified grep

(+) Good

- Help security experts audit code
- A place to collect info about bad coding practices

(-) Bad

- NOT BUG FINDERS
- Not helpful without security expertise



Advanced Static Analysis Tools: Prioritization

```
int main(int argc, char* argv[]) {
    char buf1[1024];
    char buf2[1024];
    char* shortString = "a short string";
    strcpy(buf1, shortString); /* eh. */
    strcpy(buf2, argv[0]);     /* !!! */
    ...
```

What You Won't Find

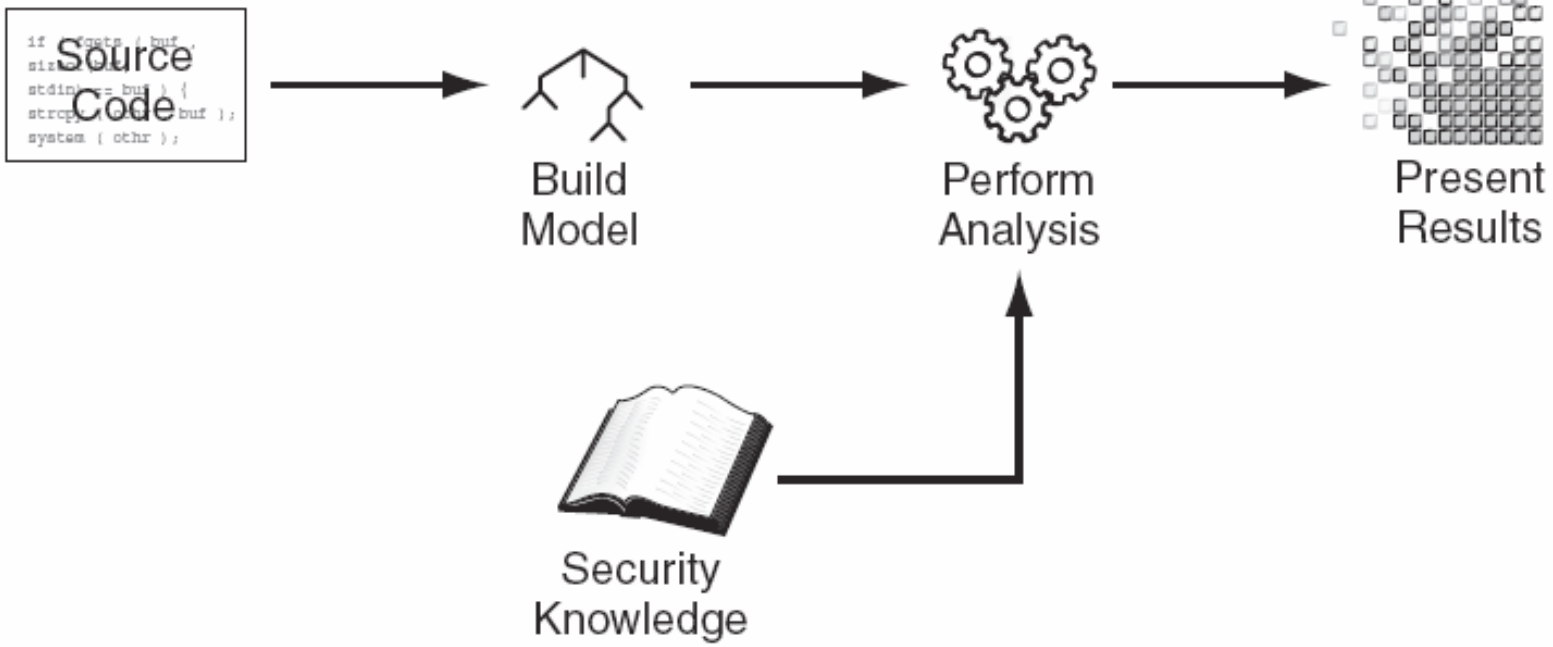
- Architecture errors
  - Microscope vs. telescope
- Bugs you're not looking for
  - Bug categories must be predefined
- System administration mistakes
- User mistakes

Security vs. Quality

- Bug finding tools focus on high confidence results
  - Bugs are cheap (plentiful)
  - Bug patterns, bug idioms
  - False alarms are killers
- Security tools focus on high risk results
  - More human input required
  - The bugs you miss are the killers

Inside a Static Analysis Tool

Under the Hood



Critical Attributes

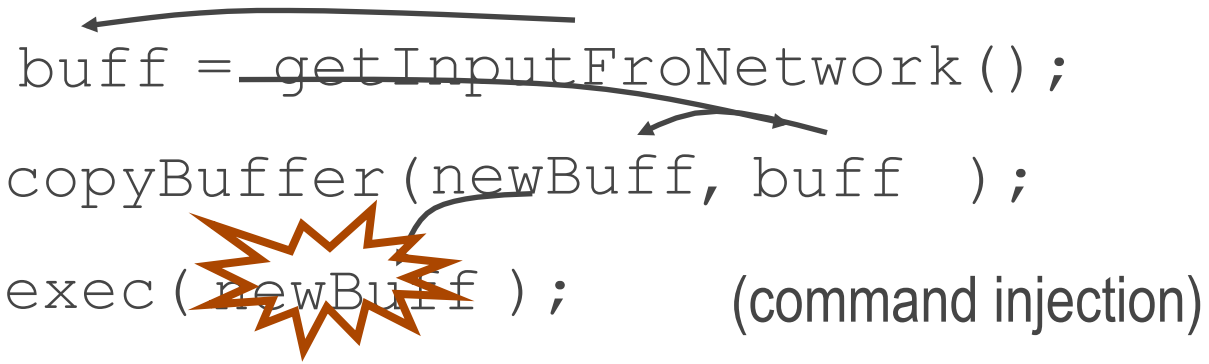
- Analysis algorithms
  - Uses the right techniques to find and prioritize issues
- Language support
  - Understands the relevant languages/dialects
- Capacity
  - Ability to gulp down millions of lines of code
- Rule set
  - Modeling rules, security properties
- Results management
  - Allow human to review results
  - Prioritization of issues
  - Control over what to report

Building a Model

- Front end looks a lot like a compiler
- Language support
  - One language/compiler is straightforward
  - Lots of combinations is harder
- Could analyze compiled code…
  - Everybody has the binary
  - No need to guess how the compiler works
  - No need for rules
- …but
  - Decompilation can be difficult
  - Loss of context hurts. A lot.
  - Remediation requires mapping to source anyway

Analysis Techniques

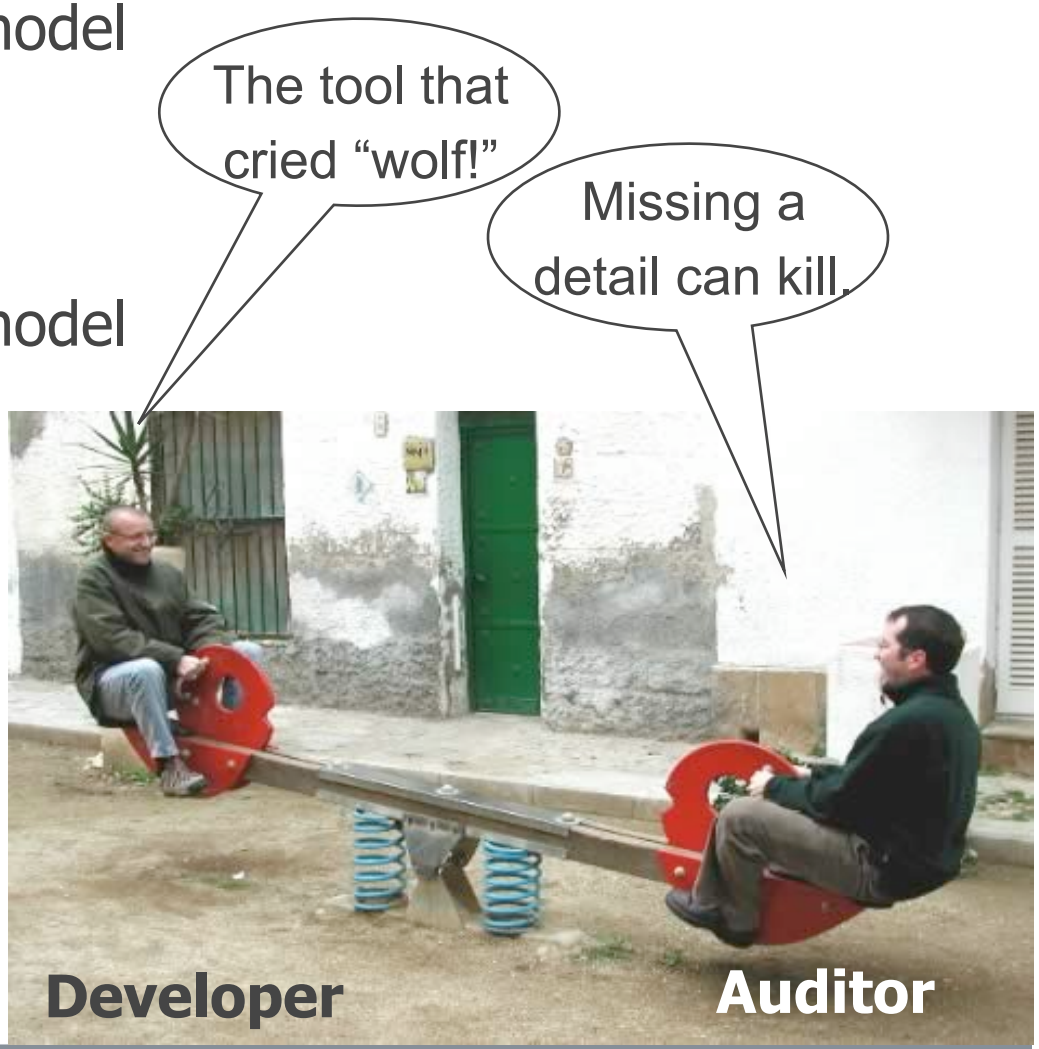
- Taint propagation
  - Trace potentially tainted data through the program
  - Report locations where an attacker could take advantage of a vulnerable function or construct



- Many other approaches, no one right answer

Only Two Ways to Go Wrong

- False positives
  - Incomplete/inaccurate model
  - Conservative analysis
- False negatives
  - Incomplete/inaccurate model
  - Missing rules
  - "Forgiving" analysis



Rules

- Specify
  - Security properties
  - Behavior of library code

```
buff = getInputFromNetwork();
copyBuffer(newBuff, buff);
exec(newBuff);
```

- Three rules to detect the vulnerability

1) **`getInputFromNetwork()`** `postcondition:`

   `return value is tainted`

2) **`copyBuffer(arg1, arg2)`** `postcondition:`

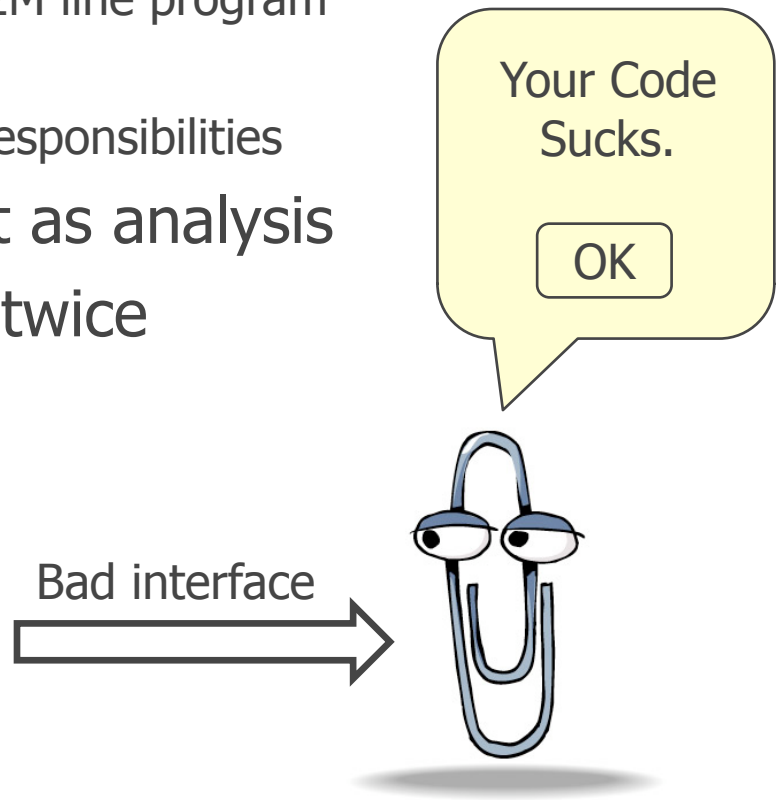
   `arg1 array values set to arg2 array values`

3) **`exec(arg)`** `precondition:`

   `arg must not be tainted`

Displaying Results

- Must convince programmer that there's a bug in the code
- Different interfaces for different scenarios:
  - Security auditor parachutes in to 2M line program
  - Programmer reviews own code
  - Programmers share code review responsibilities
- Interface is just as important as analysis
- Don't show same bad result twice



Static Analysis in Practice

Two Ways to Use the Tools

- Analyze completed programs
  - Fancy penetration test. Bleah.
  - Results can be overwhelming
  - Most people have to start here
  - Good motivator

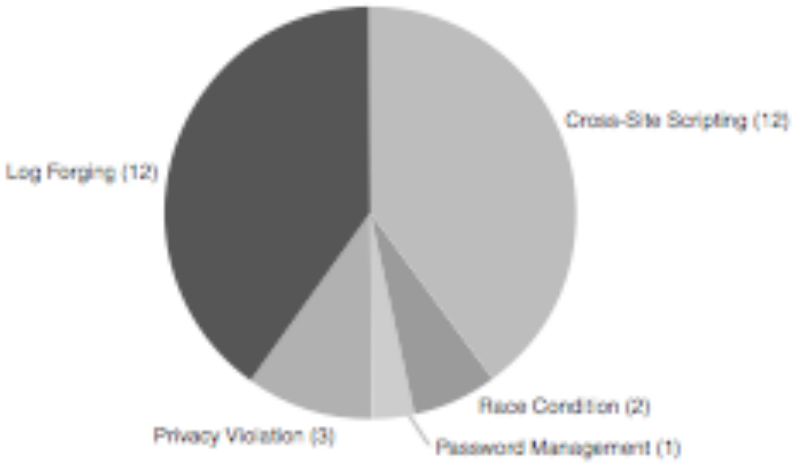
- Analyze as you write code
  - Run as part of build
  - Nightly/weekly/milestone
  - Fix as you go

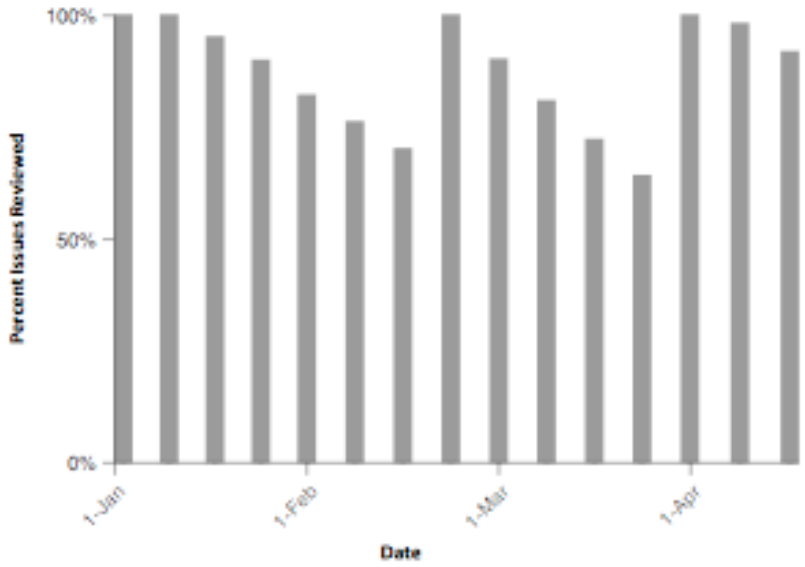
Typical Objections and Their True Meanings

Objection	Translation
"It takes too long to run."	"I think security is optional, so I don't want to do it."
"It has too many false positives."	"I think security is optional, so I don't want to do it."
"It doesn't fit with the way I work."	"I think security is optional, so I don't want to do it."

Metrics

- ?? Defect Density → Vulnerability Density ??
- NOT A GOOD RISK BAROMETER
- Good for answering questions such as
  - Which bugs do we write most often?
  - How much remediation effort is required?





Adopting a Static Analysis Tool

1) Some culture change required
   - More than just another tool
   - Often carries the banner for software security
   - Pitfall: the tool doesn't solve the problem by itself

2) Go for the throat
   - Tools detect lots of stuff. **Turn most of it off.**
   - Focus on easy-to-understand, highly relevant problems.

3) Do training up front
   - Software security training is paramount
   - Tool training is helpful too

Adopting a Static Analysis Tool

4) Measure the outcome
- Keep track of tool findings
- Keep track of outcome (issues fixed)

5) Make it your own
- Invest in customization
- Map tool against internal security standards.
  - The tools reinforce coding guidelines
  - Coding guidelines are written with automated checking in mind

6) The first time around is the worst
- Budget 2x typical cycle cost
- Typical numbers: 10% of time for security, 20% for the first time

What Next?

Seven Pernicious Kingdoms

- Catalog, define, and categorize common mistakes
- http://www.fortify.com/vulncat

- Input validation and representation
- API abuse
- Security features
- Time and state
- Error handling
- Code quality
- Encapsulation

* Environment

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Finding Bugs, Making Friends

- Sponsor open source project FindBugs
  - Quality-oriented bug finding for Java
- Academic program
  - Free **Fortify Source Code Analysis** licenses for .edu
- Java Open Review
  - http://opensource.fortifysoftware.com
- Support electronic voting machine review
  - California
  - Florida
  - more to come!

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Security Testing

- Most widely used security testing techniques are about controllability
  - Fuzzing (random input)
  - Shooting dirty data (input that often causes trouble)
- A different take: improve observability
  - Instrument code to observe runtime behavior:
    Fortify Tracer
- Benefits
  - Security-oriented code coverage
  - Vastly improved error reporting
  - Finds more bugs
- Uses rule set from static analysis tool!

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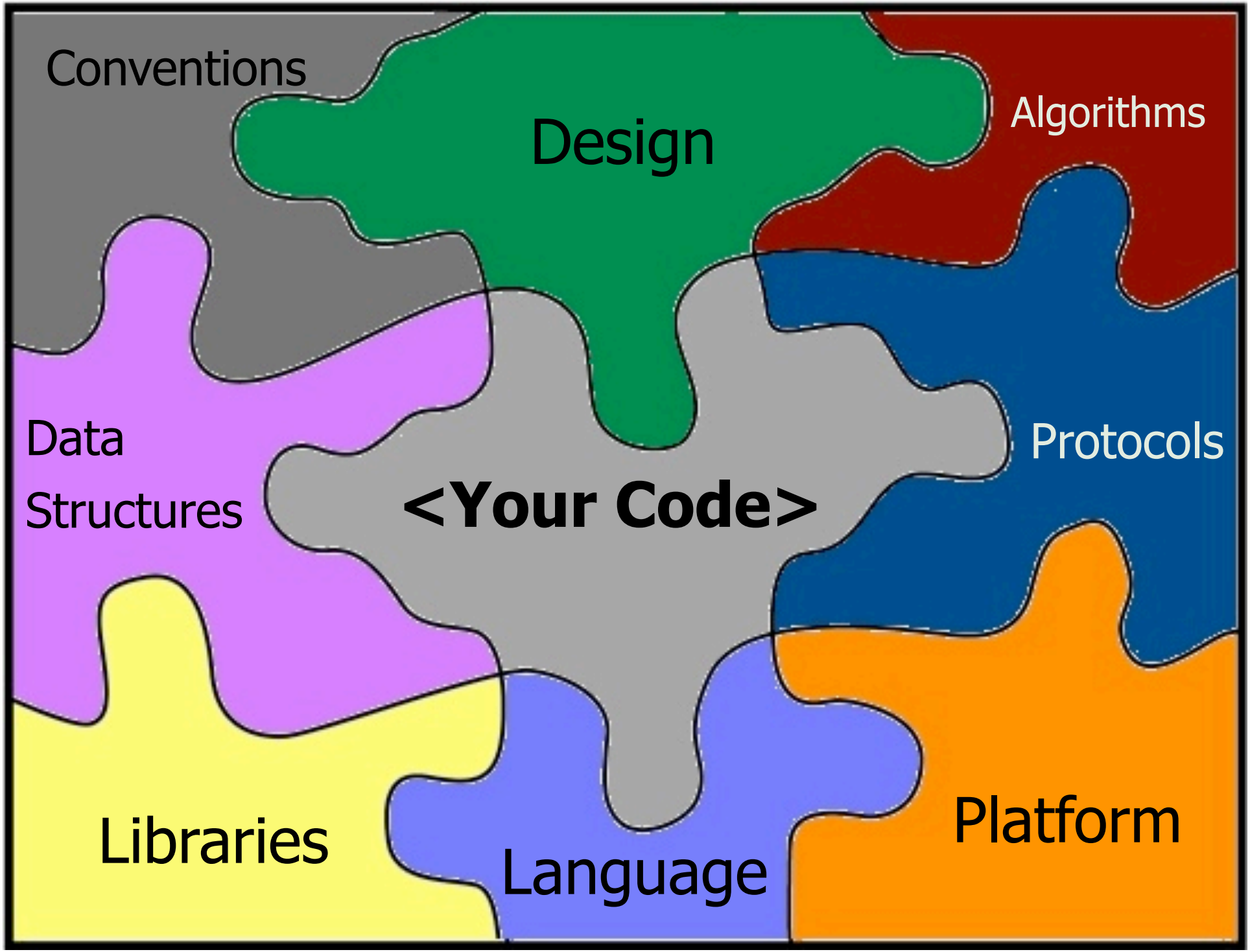
Detecting Attacks at Runtime

- If you can find bugs, can you fix them?
- Instrument program, watch it run:
  Fortify Defender
- More context than external systems
- Flexible response: log, block, etc
- Low performance overhead is a must
- Potential to detect misuse in addition to bugs

Parting Thoughts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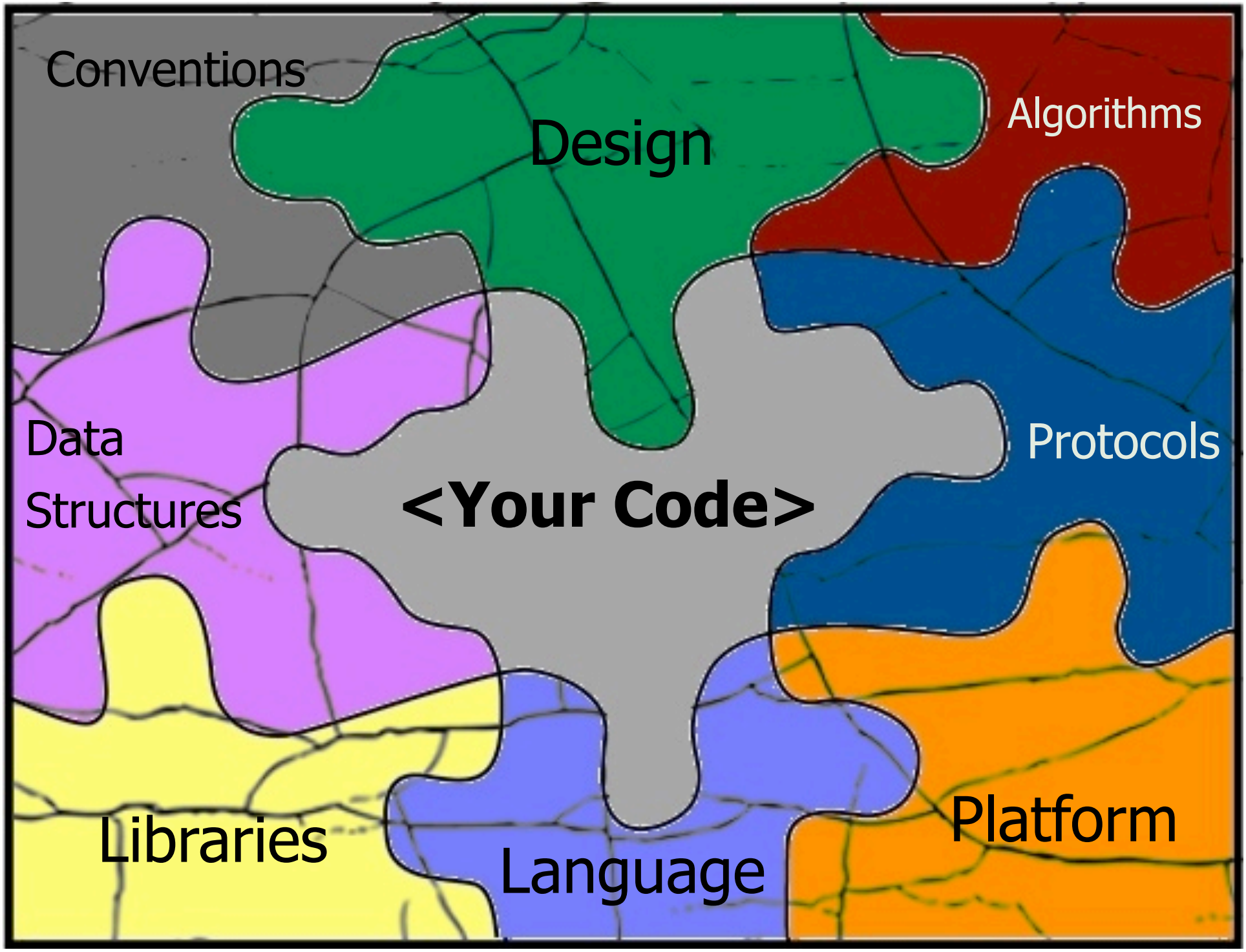
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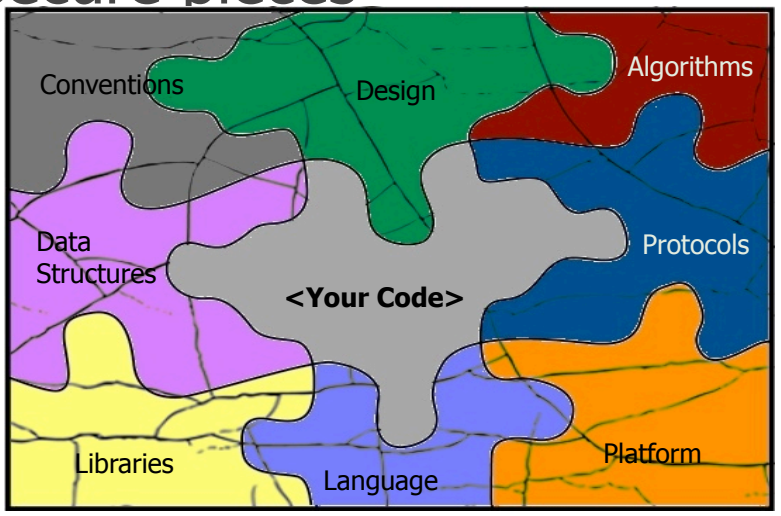
The Buck Stops With Your Code

- **Security problems everywhere you look**
  - Languages, libraries, frameworks, etc.
- **Right answer**
  - Better languages, libraries, frameworks, etc.
- **Realistic answer**
  - Build secure programs out of insecure pieces



Summary

- Mistakes happen. Plan for them.
- Security is now part of programming
- For code auditors: tools make code review efficient
- For programmers: tools bring security expertise
- Critical components of a good tool:
  - Algorithm
  - Rules
  - Interface
  - Adoption Plan

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