Bug Parades, Zombies, and the BSIMM: A Decade of Software Security

Gary McGraw, Ph.D.
Chief Technology Officer, Cigital
- Founded in 1992 to provide software security and software quality professional services
- Recognized experts in software security and software quality
  - Widely published in books, white papers, and articles
  - Industry thought leaders
in the beginning
IBM unbundles software and services from hardware in late 1960s

Unbundling created inequality in system security

Security shifts from consumers to producers

software industry blooms in 1970s
who should DO software security?

← Network security ops guys

NOBODY IN THE MIDDLE

Super rad developer dudes →
the bug parade
bug: the dreaded buffer overflow

- Overwriting the bounds of data objects
- Allocate some bytes, but the language doesn’t care if you try to use more
  
char x[12]; x[12] = '\0'
- Why was this done? Efficiency!
  
  (remember in the 70’s when code had to be tight?)

- The most pervasive security problem today in terms of reported bugs in the ‘90s
eleven years of CERT data

Security Problems (CERT)

- CERT Alerts
- Buffer overflows

Graph showing the number of security problems from 1988 to 1999, with a peak in 1997 and 1998.
void main() {
    char buf[1024];
    gets(buf);
}

- How not to get input
  - Attacker can send an infinite string!
  - Chapter 7 of K&R (page 164)
calls to avoid in C

- Very risky:
  - gets, strcpy, strcat, sprintf, scanf, sscanf, fscanf, vfscanf, vsprintf, vscanf, vsscanf, streadd, strecpy, realpath, syslog, getopt, getopt_long, getpass

- Risky:
  - strtrns, getchar, fgetc, getc, read

- Be wary:
  - bcopy, fgets, memcpy, snprintf, strccpy, strcadd, strncpy, vsnprintf

Big 1999 idea: Why not make a tool to find these for you??!
bug: race condition

- Time makes all the difference
- Atomic operations that are not atomic

Attack
bugs: Java security
a chronology Java of attack applets

- February 96: DNS flaw in JDK 1.0.1
- March 96: Path name bug
- March 96: Princeton Class Loader bug
- May 96: type casting attack
- June 96: Array type implementation error
- July 96: More type casting problems
- August 96: Flaw in Microsoft’s Java VM
- February 97: Invasion of Privacy attack applets
- March 97: JVM hole
- April 97: Code signing flaw
- May 97: Verifier problems discovered in many VMs
- July 97: Vacuum bug
- August 97: redirect bug
- July 98: ClassLoader bug
- March 99: Verifier hole
- August 99: Race condition
- October 99: Verifier hole 2
- August 2000: Brown Orifice
- October 2000: ActiveX/Java

All of these bugs have been fixed.
bug: SQL injection

- Enables an attacker to execute arbitrary SQL commands on back-end database

Example:
- PHP code inputs USERNAME and PASSWORD and passes to MySQL back-end
- USERNAME is entered as **bob**
- PASSWORD is entered as `' or USERNAME= 'bob`
- Back-end executes Select ID from USERS where `USERNAME= 'bob’ and PASSWORD= '’ or USERNAME= 'bob’`
- Instead of Select ID from USERS where `USERNAME= ‘bob’ and PASSWORD= ‘password’`
Unaltered user-controlled content in a Web server response gives an attacker the opportunity to insert HTML and scripts

This code gets rendered in a victim's browser
- Reflected (malicious links)
- Stored (by website)

OWASP top ten bug
seven pernicious kingdoms (of bugs)

- Input validation and representation
- API abuse
- Security features
- Time and state
- Error handling
- Code quality
- Encapsulation
- Environment
the bug parade FAIL

IMPLEMENTATION BUGS
- Buffer overflow
  - sprintf format
  - One-stage attacks
- Race conditions
  - TOCTOU (time of check to time of use)
- Unsafe environment variables
- Unsafe system calls
  - System()
- Untrusted input problems

ARCHITECTURAL FLAWS
- Misuse of cryptography
- Compartmentalization problems in design
- Privileged block protection failure (DoPrivilege())
- Catastrophic security failure (fragility)
- Type safety confusion error
- Insecure auditing
- Broken or illogical access control (RBAC over tiers)
- Method over-riding problems (subclass issues)
- Signing too much code

50% 50%
software security zombies
zombie ideas need repeating

- Software security seems obvious to us, but it is still catching on
- The middle market is just beginning to emerge
- Time to scale!

ZOMBIE
- Network security FAIL
- More code more bugs
- SDLC integration
- Bugs and flaws
- Badness-ometers

Experts in software security take things for granted. That’s OK, but don’t forget how far behind some firms are.
zombie: old school security is reactive

- Defend the “perimeter” with a firewall
  - To keep stuff out
- Promulgate “penetrate and patch”
- “Review” products when they’re complete
  - Throw it over the wall testing
  - Too much weight on penetration testing
- Over-rely on security functions
  - “We use SSL”

The “network guy with keys” does not really understand software testing. Builders are only recently getting involved in security.
Software Vulnerabilities

<table>
<thead>
<tr>
<th>Year</th>
<th>Software Versions</th>
<th>Vulnerabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>Win 3.1 (1990)</td>
<td>1090</td>
</tr>
<tr>
<td>2001</td>
<td>Win NT (1995)</td>
<td>2437</td>
</tr>
<tr>
<td>2002</td>
<td>Win 95 (1997)</td>
<td>4129</td>
</tr>
<tr>
<td>2003</td>
<td>NT 4.0 (1998)</td>
<td>3784</td>
</tr>
<tr>
<td>2004</td>
<td>Win 98 (1999)</td>
<td>3780</td>
</tr>
<tr>
<td>2005</td>
<td>NT 5.0 (2000)</td>
<td>5690</td>
</tr>
<tr>
<td>2006</td>
<td>Win 2K (2001)</td>
<td>8064</td>
</tr>
<tr>
<td>2007</td>
<td>XP (2002)</td>
<td>7236</td>
</tr>
</tbody>
</table>

Windows Complexity

Drivers
zombie: SDLC integration

- Integrating best practices into large organizations
  - Microsoft’s SDL
  - Cigital’s touchpoints
  - OWASP CLASP/SAMM
zombie: bugs AND flaws

gets()

attacker in the middle

BUGS

FLAWS

- Architectural risk analysis
- Customized static rules (Fidelity)
- Commercial SCA tools: Fortify, Ounce Labs, Coverity
- Open source tools: ITS4, RATS, grep()
zombie: badness-ometer

badness-ometer
zombie baby: fix the dang software

- Software security and application security today are about finding bugs
- The time has come to stop looking for new bugs to add to the list
- Which bugs in this pile should I fix?
software security touchpoints
rise of the software security group

- Cigital SSG turned fifteen in 2012
- Microsoft adopts the Secure Development Lifecycle
- Many companies have a group devoted to software security

- microsoft
- dtcc
- emc
- fidelity
- adobe
- wells fargo
- goldman sachs
- google
- qualcomm
- morgan stanley
- usaf
- dell
- pershing
- the hartford
- barclays capital
- bank of tokyo
- ups
- bank of montreal
- sterling commerce
- time warner

- cisco
- bank of america
- walmart
- finra
- vanguard
- college board
- oracle
- state street
- omgeo
- motorola
- general electric
- lockheed martin
- intuit
- vmware
- amex
- bank of ny mellon
- harris bank
- paypal
- symantec

- visa europe
- thomson/reuters
- BP
- SAP
- nokia
- ebay
- mckesson
- ABN/amro
- ING
- telecom italia
- swift
- standard life
- cigna
- AON
- coke
- mastercard
- apple
- AOL
- CA
from philosophy to HOW TO circa 2006

- Integrating best practices into large organizations
  - Microsoft’s SDL
  - Cigital’s touchpoints
  - OWASP adopts CLASP
software security touchpoints
BSIMM: software security measurement

- Real data from (42) real initiatives
- 81 measurements
- McGraw, Chess, & Migues
monkeys eat bananas

- BSIMM is not about good or bad ways to eat bananas or banana best practices
- BSIMM is about observations
- BSIMM is descriptive, not prescriptive
The Software Security Framework (SSF)

<table>
<thead>
<tr>
<th>Governance</th>
<th>Intelligence</th>
<th>SSDL Touchpoints</th>
<th>Deployment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategy and Metrics</td>
<td>Attack Models</td>
<td>Architecture Analysis</td>
<td>Penetration Testing</td>
</tr>
<tr>
<td>Compliance and Policy</td>
<td>Security Features and Design</td>
<td>Code Review</td>
<td>Software Environment</td>
</tr>
<tr>
<td>Training</td>
<td>Standards and Requirements</td>
<td>Security Testing</td>
<td>Configuration Management and Vulnerability Management</td>
</tr>
</tbody>
</table>

- Twelve practices
- An “archeology grid”
- See informIT article at [http://bsimm2.com](http://bsimm2.com)
**SSDL TOUCHPOINTS: ARCHITECTURE ANALYSIS**

Capturing software architecture diagrams, applying lists of risks and threats, adopting a process for review, building an assessment and remediation plan.

<table>
<thead>
<tr>
<th>Objective</th>
<th>Activity</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA1.1</td>
<td>get started with AA</td>
<td>perform security feature review</td>
</tr>
<tr>
<td>AA1.2</td>
<td>demonstrate value of AA with real data</td>
<td>perform design review for high-risk applications</td>
</tr>
<tr>
<td>AA1.3</td>
<td>build internal capability on security architecture</td>
<td>have SSG lead review efforts</td>
</tr>
<tr>
<td>AA1.4</td>
<td>have a lightweight approach to risk classification and prioritization</td>
<td>use risk questionnaire to rank apps</td>
</tr>
<tr>
<td>AA2.1</td>
<td>model objects</td>
<td>define/use AA process</td>
</tr>
<tr>
<td>AA2.2</td>
<td>promote a common language for describing architecture</td>
<td>standardize architectural descriptions (include data flow)</td>
</tr>
<tr>
<td>AA2.3</td>
<td>build capability organization-wide</td>
<td>make SSG available as AA resource/mentor</td>
</tr>
<tr>
<td>AA3.1</td>
<td>build capabilities organization-wide</td>
<td>have software architects lead review efforts</td>
</tr>
<tr>
<td>AA3.2</td>
<td>build proactive security architecture</td>
<td>drive analysis results into standard architectural patterns (T: sec features/design)</td>
</tr>
</tbody>
</table>
[AA1.2] **Perform design review for high-risk applications.** The organization learns about the benefits of architecture analysis by seeing real results for a few high-risk, high-profile applications. If the SSG is not yet equipped to perform an in-depth architecture analysis, it uses consultants to do this work. Ad hoc review paradigms that rely heavily on expertise may be used here, though in the long run they do not scale.
real-world data (42 firms)

- Initiative age
  - Average: 5.5 years
  - Newest: 1
  - Oldest: 16
  - Median: 4

- SSG size
  - Average: 19.2
  - Smallest: 0.5
  - Largest: 100
  - Median: 8

Average SSG size: 1.99% of dev group size

- Satellite size
  - Average: 42.7
  - Smallest: 0
  - Largest: 350
  - Median: 15

- Dev size
  - Average: 5183
  - Smallest: 11
  - Largest: 30,000
  - Median: 1675
### BSIMM3 scorecard

- **109 Activities**
- **3 levels**
- **Top 12 activities**
  - 69% cutoff
  - 29 of 42 firms
- Comparing scorecards between releases is interesting

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<tr>
<td>Activity</td>
<td>Oberved</td>
<td>Activity</td>
<td>Oberved</td>
</tr>
<tr>
<td>SM1.4</td>
<td>30 (SM1.4)</td>
<td>13 (SM1.4)</td>
<td>34 (FT1.1)</td>
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<tr>
<td>SM1.3.2</td>
<td>26 (SM1.3.2)</td>
<td>29 (SM1.3.2)</td>
<td>29 (FT1.2)</td>
</tr>
<tr>
<td>SM1.3.3</td>
<td>28 (SM1.3.3)</td>
<td>24 (SM1.3.3)</td>
<td>24 (FT1.3)</td>
</tr>
<tr>
<td>SM1.4</td>
<td>38 (SM1.4)</td>
<td>13 (SM1.4)</td>
<td>28 (FT2.1)</td>
</tr>
<tr>
<td>SM1.4.6</td>
<td>30 (SM1.4.6)</td>
<td>25 (SM1.4.6)</td>
<td>9 (FT2.2)</td>
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<td>SM1.4.1</td>
<td>18 (SM1.4.1)</td>
<td>12 (SM1.4.1)</td>
<td>6 (FT2.3)</td>
</tr>
<tr>
<td>SM1.2.2</td>
<td>22 (SM1.2.2)</td>
<td>12 (SM1.2.2)</td>
<td>12 (FT3.1)</td>
</tr>
<tr>
<td>SM1.3.3</td>
<td>22 (SM1.3.3)</td>
<td>15 (SM1.3.3)</td>
<td>8 (FT3.2)</td>
</tr>
<tr>
<td>SM1.3.3</td>
<td>20 (SM1.3.3)</td>
<td>3 (SM1.3.3)</td>
<td>4 (FT3.3)</td>
</tr>
<tr>
<td>SM3.2</td>
<td>13 (SM3.2)</td>
<td>5 (SM3.2)</td>
<td>5 (FT3.4)</td>
</tr>
</tbody>
</table>

| (CP1.1)    | 35 (SF1.1)   | 37 (SF1.1)       | 19 (SF1.1) | 19 (SF1.1) |
| (CP1.2)    | 38 (SF1.2)   | 29 (SF1.2)       | 20 (SF1.2) | 38 (SF1.2) |
| (CP1.3)    | 34 (SF1.3)   | 23 (SF1.3)       | 29 (SF1.3) | 19 (SF1.3) |
| (CP1.4)    | 19 (SF1.4)   | 15 (SF1.4)       | 14 (SF1.4) | 7 (SF1.4)  |
| (CP2.1)    | 27 (SF2.1)   | 14 (SF2.1)       | 19 (SF2.1) | 22 (SF2.1) |
| (CP2.2)    | 20 (SF2.2)   | 8 (SF2.2)        | 17 (SF2.2) | 11 (SF2.2) |
| (CP2.3)    | 18 (SF2.3)   | 9 (SF2.3)        | 13 (SF2.3) | 13 (SF2.3) |
| (CP2.4)    | 26 (SF2.4)   | 12 (SF2.4)       | 3 (SF2.4)  | 3 (SF2.4)  |
| (CP2.5)    | 7 (SF2.5)    | 3 (SF2.5)        | 5 (SF2.5)  | 5 (SF2.5)  |
| (CP2.6)    | 11 (SF2.6)   | 5 (SF2.6)        | 3 (SF2.6)  | 3 (SF2.6)  |
| (CP2.7)    | 8 (SF2.7)    | 9 (SF2.7)        | 4 (SF2.7)  | 6 (SF2.7)  |

| (CP3.1)    | 33 (SR1.1)   | 31 (SR1.1)       | 32 (SM1.1) | 33 (SM1.1) |
| (CP3.2)    | 11 (SR1.2)   | 22 (SR1.2)       | 12 (SM1.2) | 35 (SM1.2) |
| (CP3.3)    | 5 (SR1.3)    | 25 (SR1.3)       | 28 (SM1.3) | 29 (SM1.3) |
| (CP3.4)    | 11 (SR1.4)   | 17 (SR1.4)       | 20 (SM1.4) | 27 (SM1.4) |
| (CP3.5)    | 16 (SR1.5)   | 10 (SR1.5)       | 7 (SM1.5)  | 22 (SM1.5) |
| (CP3.6)    | 18 (SR1.6)   | 17 (SR1.6)       | 9 (SM1.6)  | 5 (SM1.6)  |
| (CP3.7)    | 20 (SR1.7)   | 18 (SR1.7)       | 9 (SM1.7)  | 6 (SM1.7)  |
| (CP3.8)    | 9 (SR1.8)    | 17 (SR1.8)       | 4 (SM1.8)  | 4 (SM1.8)  |
| (CP3.9)    | 6 (SR1.9)    | 19 (SR1.9)       | 4 (SM1.9)  | 4 (SM1.9)  |
| (CP3.10)   | 4 (SR1.10)   | 9 (SR1.10)       | 4 (SM1.10) | 4 (SM1.10) |
| (CP3.11)   | 7 (SR1.11)   | 19 (SR1.11)      | 4 (SM1.11) | 4 (SM1.11) |
| (CP3.12)   | 6 (SR1.12)   | 5 (SR1.12)       | 4 (SM1.12) | 4 (SM1.12) |
BSIMM3 as a measuring stick

- Compare a firm with peers using the high water mark view
- Descriptive (not prescriptive)
- Incredible insight for planning
1. Top 12 activities
   - green = good?
   - red = bad?

2. “Blue shift” practices to emphasize
   - activities you should maybe think about in blue
BSIMM3 to BSIMM4

- BSIMM3 released September 2011 under creative commons
  - [http://bsimm.com](http://bsimm.com)
  - Italian and German translations
  - BSIMM is a yardstick
  - Use it to see where you stand
  - Use it to figure out what your peers do

- BSIMM3 → BSIMM4
  - BSIMM is growing
  - Target of 50 firms/100 measures
where to learn more
SearchSecurity & justice league

- www.searchsecurity.com
- No-nonsense monthly security column by Gary McGraw debuts in April

- www.cigital.com/~gem/writing
- In-depth thought leadership blog from the Cigital Principals
  - Scott Matsumoto
  - Gary McGraw
  - Sammy Migues
  - Craig Miller
  - John Steven
IEEE security & privacy + silver bullet

- Building Security In
- Software Security Best Practices column edited by John Steven
- www.computer.org/security/bsisub/

- www.cigital.com/silverbullet
Software Security: the book

- How to DO software security
  - Best practices
  - Tools
  - Knowledge
- Cornerstone of the Addison-Wesley Software Security Series
- www.swsec.com
http://bsimm.com

WE NEED GREAT PEOPLE (see Julian)

See the Addison-Wesley Software Security series

Send e-mail: gem@cigital.com

“So now, when we face a choice between adding features and resolving security issues, we need to choose security.”

-Bill Gates