Secure Programming Lecture 2: Landscape

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Introduction

This lecture introduces the industry context behind software security.

- **example** of a vulnerability and its origin
  - *threat -> vulnerability -> response*
- **timeline** of attacks, notifications, responses
- **security advisories** and **CVE-IDs**
- implementing a **software security strategy** in an organisation

Outline

Threat

General aim: *services running on Unix systems should be robust against local and remote attackers*.

Otherwise: attackers may exploit a service to cause a DoS attack, gain access to a system, etc.

For a specific system, a threat analysis should consider the kinds of attackers and their motives (local? remote? what is being protected?) and then all the services running on the system.

Question. What's the easiest form of defence?

A Vulnerability

A security review should first discover (and then monitor) relevant published **security advisories**.

For high value situations (and application code), dedicated review may be needed.

Jan. 7, 2014 - Stack buffer overflow in parsing of BDF font files in libXfont

CVE-2013-6462: An authenticated X client can cause an X server to read a font file that overflows a buffer on the stack in the X server, potentially leading to crash and/or privilege escalation in setuid servers. The fix is included in libXfont 1.4.7. See the advisory for more details.

What is a BDF file?

```
STARTFONT 2.1
COMMENT
COMMENT  Copyright (c) 1999, Thomas A. Fine
COMMENT
...
FONT -atari-small
SIZE 11 75 75
FONTBOUNDINGBOX 4 8 0 -1
STARTCHAR C000
ENCODING 0
SWIDTH 1 0
DWIDTH 4 0
BBX 4 8 0 -1
BITMAP
00
00
...
```

- BDF = **B**itmap **D**istribution **F**ormat
- A (mostly) obsolete font format by Adobe

Advisory: **Description**

Scanning of the libXfont sources with the *cppcheck* static analyzer included a report:

```
[lib/libXfont/src/bitmap/bdfread.c:341]: (warning)
  scanf without field width limits can crash...
```

Evaluation of this report by X.Org developers concluded that a BDF font file containing a longer than expected string could **overflow the buffer on the stack**. Testing in X servers built with Stack Protector resulted in an immediate crash when reading a user-provided specially crafted font.

As libXfont is used to read user-specified font files in all X servers distributed by X.Org, including the Xorg server which is often run with root privileges or as setuid-root in order to access hardware, this bug may lead to an **unprivileged user acquiring root privileges** in some systems.

Advisory: **Affected Versions**

This bug appears to have been introduced in the initial RCS version 1.1 **checked in on 1991/05/10, and is thus believed to be present in every X11 release starting with X11R5** up to the current libXfont 1.4.6. (Manual inspection shows it is present in the sources from the X11R5 tarballs, but not in those from the X11R4 tarballs.)

The vulnerability in the code

```
338  char        charName[100];
339  int         ignore;
340
341  if (sscanf((char *) line, "STARTCHAR %s", charName) != 1) {
342  bdfError("bad character name in BDF file\n");
343      goto BAILOUT; /* bottom of function, free and return error */
344  }
```

The vulnerability in the code

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```

SYNOPSIS

```
#include <stdio.h>

int sscanf(const char *str, const char
*format, ...);
```

DESCRIPTION

`sscanf()` scans input from the character string pointed to by `str`, according to `format` string. This may contain conversions; results are stored in locations pointed to by the pointer arguments that follow `format`.

Advisory: **Fix**

```
diff --git a/src/bitmap/bdfread.c b/src/bitmap/bdfread.c
index e2770dc..e11c5d2 100644
--- a/src/bitmap/bdfread.c
+++ b/src/bitmap/bdfread.c
@ -338,7 +338,7 @ bdfReadCharacters(FontFilePtr file, FontPtr pFont, b
    char        charName[100];
    int         ignore;

-   if (sscanf((char *) line, "STARTCHAR %s", charName) != 1) {
+   if (sscanf((char *) line, "STARTCHAR %99s", charName) != 1) {
        bdfError("bad character name in BDF file\n");
        goto BAILOUT; /* bottom of function, free and return error */
    }
```

The text above is an example of a *context diff* which shows the difference between two file versions. The **patch** command can be used to update the older file given this text. You need to know how to make and apply patches for this course. See ‘man patch‘ on a Linux/Unix system.

Defences

Options:

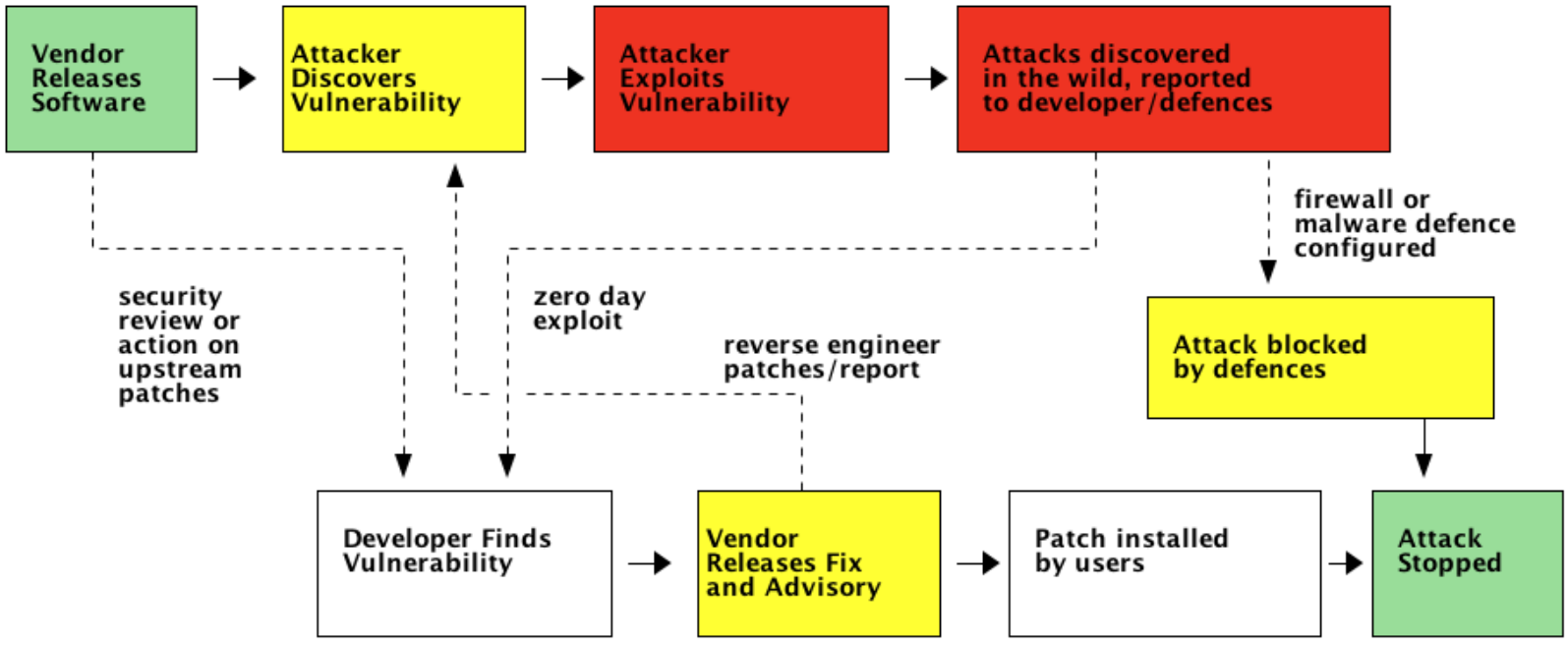
- Disable service
- Repair service: *downstream* updates
- Mitigate impact of attack

In running systems:

- Have there been past attacks?
- Can we check for future ones?

Outline

Vulnerability and attacks timeline



Security advisories

Security **advisories** (aka **bulletins**) are issued by software vendors

- *public* feeds, also *private* at earlier stages
- advance notification to high-value customers, security companies
  - maybe before patches are available
  - **Q.** is that a good idea?
- public advisory usually when update available
  - may be *coordinated* among vendors and upstream developers

Various people (sys admins, downstream software devs, users. . .) should monitor and act on advisories.

Security advisory format

Each vendor has own format. Typical information:

- Name, date, unique identification
- Criticality
- Affected products
- Solution

Varying amounts of information given:

- enough information to construct an exploit?
- if not, attackers may reverse engineer patches/updates anyway
- disclosure has to be planned carefully
  - typically by coordinated disclosure

Advisory for libXfont vulnerability

Jan. 7, 2014 - Stack buffer overflow in parsing of BDF font files in libXfont

CVE-2013-6462: An authenticated X client can cause an X server to read a font file that overflows a buffer on the stack in the X server, potentially leading to crash and/or privilege escalation in setuid servers. The fix is included in libXfont 1.4.7. See the advisory for more details.

Advisory on xorg-announce

X.Org Security Advisory: CVE-2013-6462: Stack buffer overflow in
   parsing of BDF font files in libXfont
Alan Coopersmith alan.coopersmith at oracle.com
Tue Jan 7 08:43:23 PST 2014

X.Org Security Advisory: January 7, 2014 - CVE-2013-6462
Stack buffer overflow in parsing of BDF font files in libXfont
==========

Description:
==========

Scanning of the libXfont sources with the cppcheck static analyzer
included a report of:

  [lib/libXfont/src/bitmap/bdfread.c:341]: (warning)
      scanf without field width limits can crash with huge input data.

Advisory on Red Hat enterprise-watch-list

```
-----BEGIN PGP SIGNED MESSAGE-----
Hash: SHA1

====================================================================
                    Red Hat Security Advisory

Synopsis:           Important: libXfont security update
Advisory ID:        RHSA-2014:0018-01
Product:            Red Hat Enterprise Linux
Advisory URL:       https://rhn.redhat.com/errata/RHSA-2014-0018.html
Issue date:         2014-01-10
CVE Names:          CVE-2013-6462
====================================================================

1. Summary:

Updated libXfont packages that fix one security issue are now
available for Red Hat Enterprise Linux 5 and 6.

The Red Hat Security Response Team has rated this update as having
important security impact.
...
```

2. Relevant releases/architectures:

RHEL Desktop Workstation (v. 5 client) - i386, x86_64
Red Hat Enterprise Linux (v. 5 server) - i386, ia64, ppc, s390x, x86_6
Red Hat Enterprise Linux Desktop (v. 5 client) - i386, x86_64
Red Hat Enterprise Linux Desktop (v. 6) - i386, x86_64
Red Hat Enterprise Linux Desktop Optional (v. 6) - i386, x86_64
Red Hat Enterprise Linux HPC Node (v. 6) - x86_64
Red Hat Enterprise Linux HPC Node Optional (v. 6) - x86_64
Red Hat Enterprise Linux Server (v. 6) - i386, ppc64, s390x, x86_64
Red Hat Enterprise Linux Server Optional (v. 6) - i386, ppc64, s390x,
Red Hat Enterprise Linux Workstation (v. 6) - i386, x86_64
Red Hat Enterprise Linux Workstation Optional (v. 6) - i386, x86_64

3. Description:

The libXfont packages provide the X.Org libXfont runtime library. X.Org is an open source implementation of the X Window System.

A stack-based buffer overflow flaw was found in the way the libXfont library parsed Glyph Bitmap Distribution Format (BDF) fonts. A malicious, local user could exploit this issue to potentially execute arbitrary code with the privileges of the X.Org server. (CVE-2013-6462)

Users of libXfont should upgrade to these updated packages, which contain a backported patch to resolve this issue. All running X.Org server instances must be restarted for the update to take effect.

4. Solution:

Before applying this update, make sure all previously-released errata relevant to your system have been applied.

This update is available via the Red Hat Network. Details on how to use the Red Hat Network to apply this update are available at https://access.redhat.com/kb/docs/DOC-11259

5. Bugs fixed (https://bugzilla.redhat.com/):

1048044 - CVE-2013-6462 libXfont: stack-based buffer overflow flaw when parsing Glyph Bitmap Distribution Format (BDF) fonts

6. Package List:

Red Hat Enterprise Linux Desktop (v. 5 client):

Source:
ftp://ftp.redhat.com/pub/redhat/linux/enterprise/5Client/en/os/SRPMS/l

i386:
libXfont-1.2.2-1.0.5.el5_10.i386.rpm
libXfont-debuginfo-1.2.2-1.0.5.el5_10.i386.rpm
...
...

7. References:

https://www.redhat.com/security/data/cve/CVE-2013-6462.html
https://access.redhat.com/security/updates/classification/#important

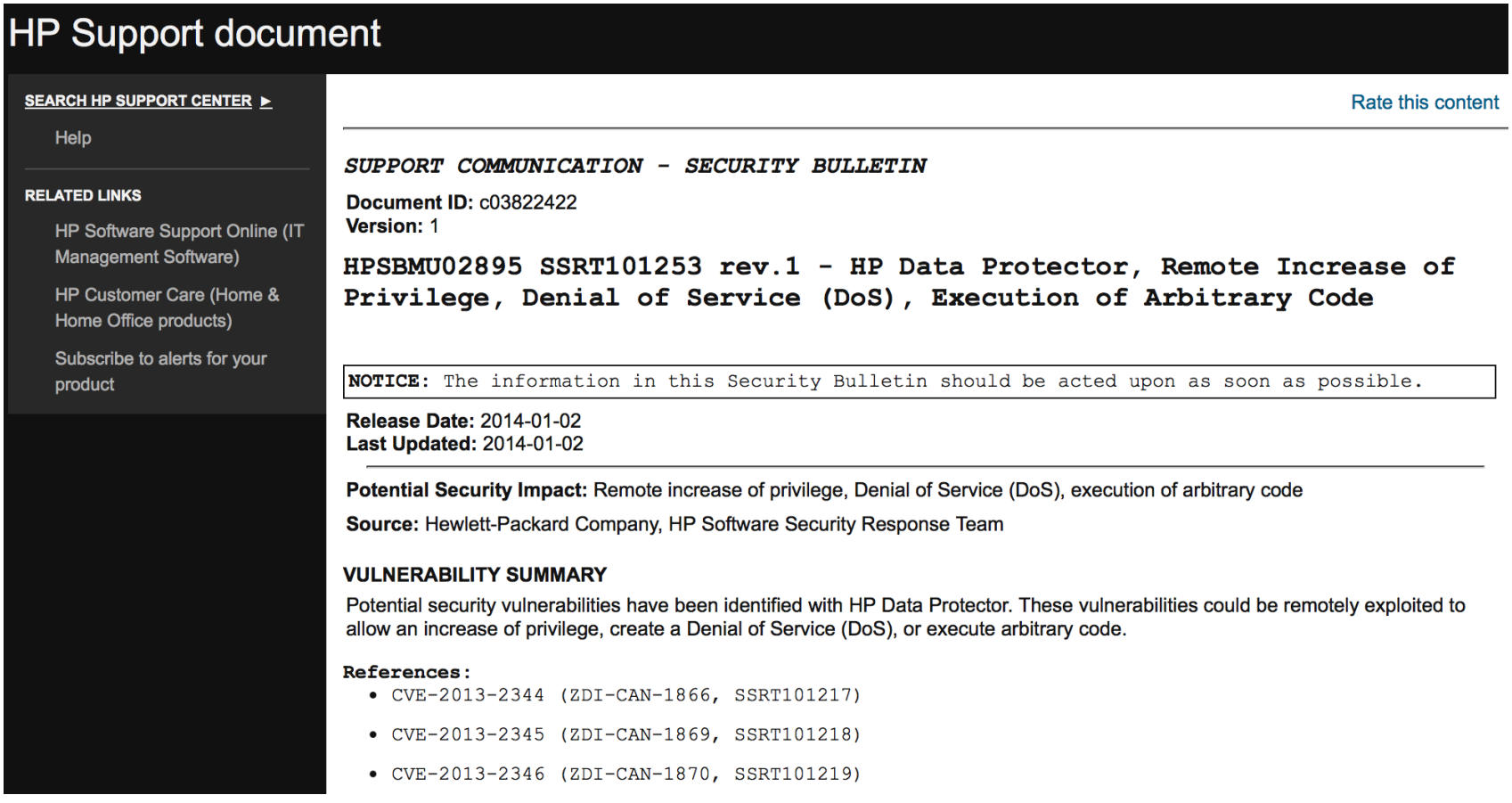
8. Contact:

The Red Hat security contact is <secalert redhat com>. More
contact details at
https://access.redhat.com/security/team/contact/

-----BEGIN PGP SIGNATURE-----
Version: GnuPG v1.4.4 (GNU/Linux)

iD8DBQFSz8HSXlSAg2UNWIIRAvo5AJ4976ATNgp8mmoyRgObDFnCvOP4zACfYWJc
f9VhkwpGzE3y3jtSD9fupVg=
=T7Wm
-----END PGP SIGNATURE-----

Example: HP Data Protector



HP Support document

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SUPPORT COMMUNICATION - SECURITY BULLETIN

Document ID: c03822422
Version: 1

HPSBMU02895 SSRT101253 rev.1 - HP Data Protector, Remote Increase of Privilege, Denial of Service (DoS), Execution of Arbitrary Code

NOTICE: The information in this Security Bulletin should be acted upon as soon as possible.

Release Date: 2014-01-02
Last Updated: 2014-01-02

Potential Security Impact: Remote increase of privilege, Denial of Service (DoS), execution of arbitrary code

Source: Hewlett-Packard Company, HP Software Security Response Team

VULNERABILITY SUMMARY

Potential security vulnerabilities have been identified with HP Data Protector. These vulnerabilities could be remotely exploited to allow an increase of privilege, create a Denial of Service (DoS), or execute arbitrary code.

References:

- CVE-2013-2344 (ZDI-CAN-1866, SSRT101217)
- CVE-2013-2345 (ZDI-CAN-1869, SSRT101218)
- CVE-2013-2346 (ZDI-CAN-1870, SSRT101219)

What is HP Data Protector?

Big data causes big backup challenges

How was this vulnerability found?

- Zero Day Initiative, started by TippingPoint, a network security company
  - part of 3Com, now HP
- Idea of *crowd-sourcing* vulnerability discovery
- Finding many vulnerabilities in enterprise software
  - HP, Microsoft, CISCO, . . .
- Incentive programme rewarding participants
  - $ reward, bonuses like DEFCON attendance
  - advantages: independence, wider knowledge
  - and presumably cheaper than direct employment

Outline

What is CVE?

- Started in 1999, originally at CERT
  - CVE = Common Vulnerability *Enumeration*
- Aim: standardise identification of vulnerabilities
  - before CVE, each vendor used its own scheme
  - confusing multiple advisories for same problem
- Each vendor/distributor has own advisory channel
  - CVE allows cross referencing, public standard ID
  - Users or customers can check how CVEs are handled
- Moved to MITRE, a US R& D outfit
  - CVE = **Common Vulnerabilities and Exposures**
- ITU-T adopted in 2011 as international recommendation, X.CVE

Vulnerabilities versus Exposures

Vulnerability A mistake that can be used by a hacker to violate a “reasonable” security policy for a system (e.g., executing commands as another user, violating access restrictions, conducting a DoS attack)
Example: smurf vulnerability (ping server responds to broadcast address)

Exposure A system configuration issue or mistake in software that can be used by a hacker as a stepping-stone into a system or network, e.g., gathering information, hiding activities.
Example: running open ‘finger‘ service; allows attacker to probe network

CVE Identifiers

Consist of:

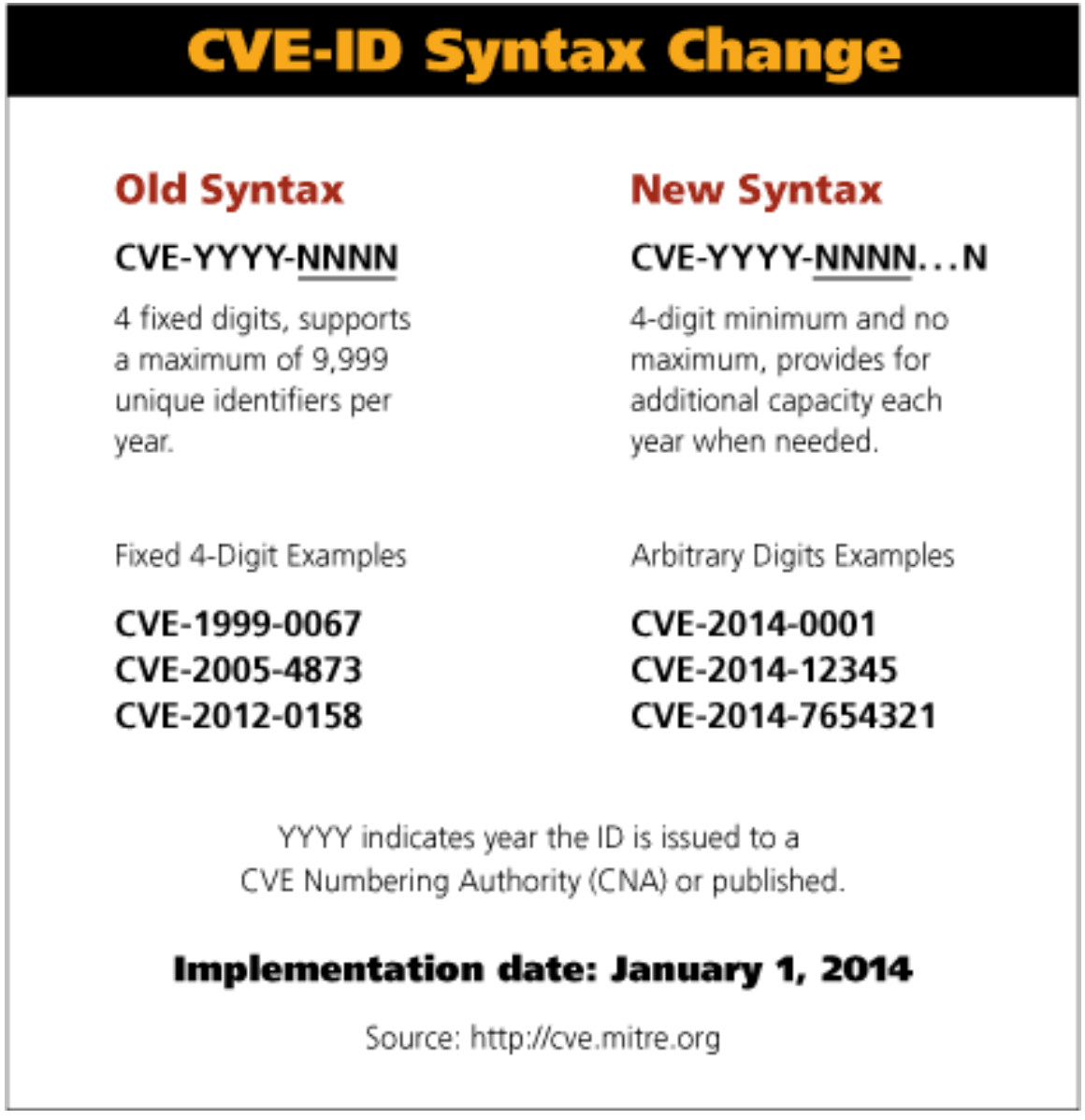
- CVE ID (number): **CVE-1999-0067**
- Brief description of vulnerability or exposure
- References, e.g., to reports or advisories

CVE IDs

CVE-ID Syntax Changing on January 1, 2014

Due to the ever increasing volume of public vulnerability reports, the CVE Editorial Board and MITRE determined that the Common Vulnerabilities and Exposures (CVE®) project should change the syntax of its standard vulnerability identifiers so that CVE can track more than 10,000 vulnerabilities in a single year.

New CVE ID format



Creating CVE Identifiers

1. Discover a potential V or E
2. Get a CVE Numbering Authority to give a number
   - MITRE, big vendors (Apple, Google, MS, Ubuntu,. . .)
   - Numbers reserved in blocks; “instantly” available
3. CVE ID number shared among disclosure parties
4. Advisory published, including CVE-ID number
5. MITRE updates master list

Only published CVE-ID Numbers are kept in master list.

CVE Compatibility

- Standard for “interoperability” or “comparability”
- For products and services
- Has some official requirements certified by MITRE
  - ownership by legal entity
  - responsibility, answering to reviews
- Capability required for tools, web sites
  - *CVE searchable*
  - Use standard document formats

Outline

BSIMM: Building Security In Maturity Model

- BSIMM is a *Maturity Model* for real-world best practices in software-producing companies
  - examines *Software Security Initiatives* (SSIs)
  - provides a “measuring stick”, state-of-the-art
- Introduced by Gary McGraw and others
  - Author of *Software Security: Building Security In*
- Inspired by **Capability Maturity Model (CMM)** (late 80s-90s)
  - model of software development processes
  - *maturity* = degree of formality/rigour of process
  - 5 Levels: *chaotic*, *repeatable*, *defined*, *managed*, *optimizing*
- Now at BSIMM-7, October 2016. Around 90 initiatives studied.

BSIMM goals

For organisations starting/running a Software Security Initiative, BSIMM aims to:

- Inform risk management decisions
- Clarify “right thing to do” for those involved
- Reduce costs via standard, repeatable processes
- Improve code quality

This is done by planning a *Software Security Initiative*, implementing activities selected from BSIMM. Activities can be roled out according to the maturity level of the organisation.

Implementing a SSI

May be a **serious effort** for a large organisation to implement, and require a big budget.

Large companies can have:

- tens of thousands of software developers
- hundreds or thousands of applications in development
- similarly many applications in deployment or sale

Systematic, explicit organisation of security goals are needed to mange software security effectively.

The BSIMM Software Security Framework

BSIMM defines a *Software Security Framework* which describes

- **12 practices** organised into **4 domains**
  - Governance, Intelligence, Development, Deployment
- Each practice involves numerous **activities**
- Each practice split into **maturity levels 1–3**
  - each maturity level has several activities
- Now covers over **100** activities
- New activities added when they appear in >1 org

BSIMM Domains and Practices

Governance

Management, measurement, training.

- **SM** Strategy and Metrics
- **CP** Compiliance and Policy
- **T** Training

Intelligence

Collecting data, issuing guidance, threat modelling

- **AM** Attack Models
- **SFD** Security Features and Design
- **SR** Standards and Requirements

The BSIMM Software Security Framework

Secure Software Development Lifecycle (SSDL) Touchpoints

Software development artifacts and processes

AA Architecture Analysis
CR Code Review
ST Security Testing

Deployment

Configuration, maintenance, environment security

PT Penetration Testing
SE Software Environment
CMVM Configuration Management and Vulnerability Management

Governance: Example maturity levels

Strategy and Metrics (SM) maturity levels:

1. Common understanding of direction, strategy
   - everyone involved in creating software understands written software security goals
   - company management understand strategy for achieving
2. Align behaviour with strategy
   - software security leadership roles filled
3. Risk-based portfolio management
   - top-level management learns about risk for each application

Governance: Example activity

SM 1.4: Identify gate locations, gather necessary artifacts

The software security process will involve release gates/ checkpoints/milestones at one or more points in the SDLCs. First steps:

1. identify gate locations that are compatible with existing development practices and
2. begin gathering the input necessary for making a go/no go decision.

Importantly at this stage, the gates are not enforced. . . .

Governance: Example activity

SM 2.2: Enforce gates with measurements and track exceptions

SDLC security gates are now enforced: in order to pass a gate, a project must either meet an established measure or obtain a waiver. Even recalcitrant project teams must now play along. The SSG tracks exceptions. . . .

Personal experience (2009-): mixed evidence

- Selling Software Quality tool for safety/security
  - Java static analysis for concurrency
- Went into a number of large financial services orgs
- Found range of maturity levels. . .

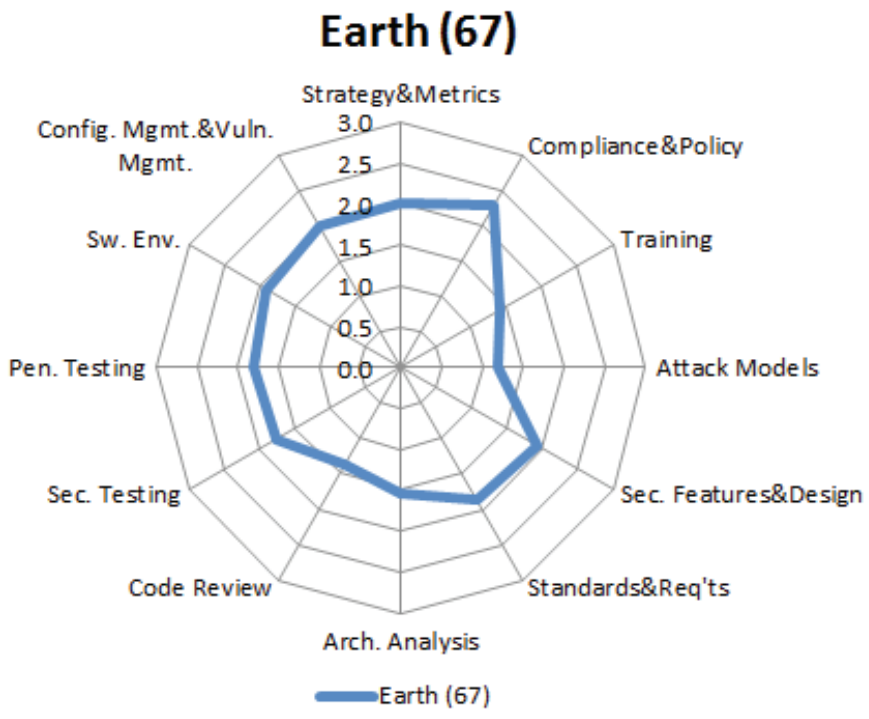
BSIMM-V survey (2015)

- 64 organisations nterviewed
- Range of industry sectors
  - financial services
  - independent software vendors
  - cloud, retail, security, healthcare, media, . . .
- Results confidential. Some companies named, e.g.:
  - Adobe, Intel, McAfee, Microsoft
  - Bank of America, Capital One, Goldman Sachs, HSBC
  - PayPal, Visa
  - Marks and Spencer
- All orgs run a **Software Security Group (SSG)**
  - responsible for carrying out software security
  - mix of roles
  - essential first step: **management buy-in**
- SSGs quite young (average 5 years)

BSIM-V results: score card

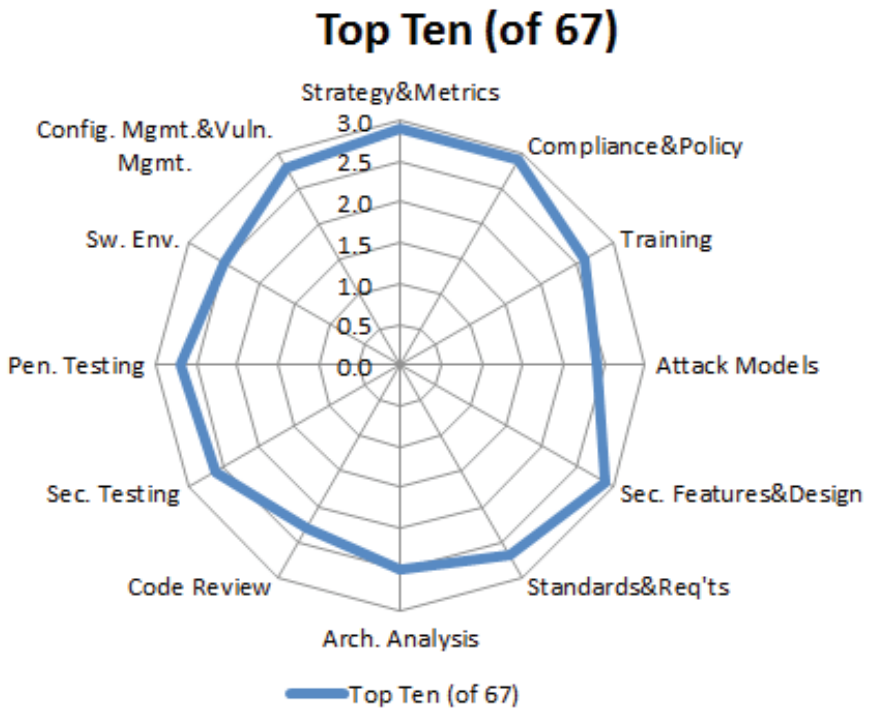
Governance		Intelligence		SSDL Touchp	
Activity	Observed	Activity	Observed	Activity	Ob
[SM1.1]	44	[AM1.1]	21	[AA1.1]	
[SM1.2]	34	[AM1.2]	43	[AA1.2]	
[SM1.3]	34	[AM1.3]	30	[AA1.3]	
[SM1.4]	57	[AM1.4]	12	[AA1.4]	
[SM1.6]	36	[AM1.5]	42	[AA2.1]	
[SM2.1]	26	[AM1.6]	16	[AA2.2]	
[SM2.2]	31	[AM2.1]	7	[AA2.3]	
[SM2.3]	27	[AM2.2]	11	[AA3.1]	
[SM2.5]	20	[AM3.1]	4	[AA3.2]	
[SM3.1]	16	[AM3.2]	6		
[SM3.2]	6				

BSIM-V results: average best practice

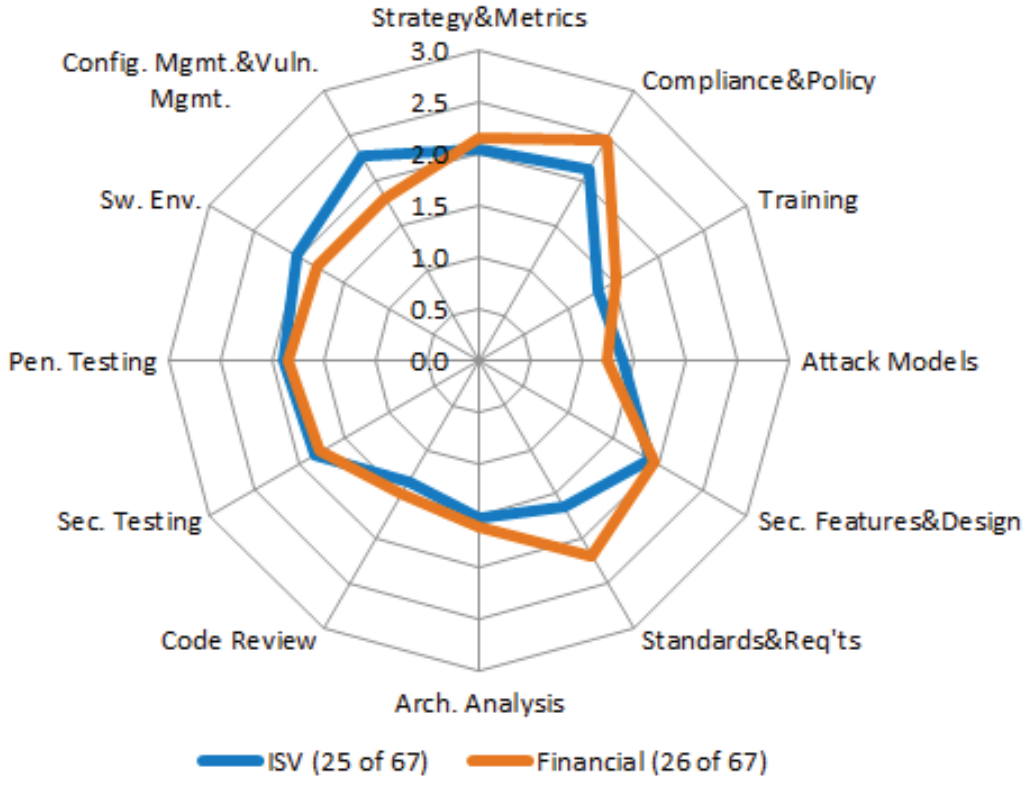


- uses spider diagram to show the “high watermark” in each of the 12 practices, i.e., the highest maturity level achieved
- for set of companies, take average high watermark

BSIM-V results: top 10



BSIM-V results: sector comparison



New activities added

Results are used to identify most common (core) activities in each practice and discover new activities.

BSIM 6 Operate a bug bounty programme
BSIM 7 Use containerisation to help security

6% of survey operated a bug bounty in Oct 2015.

BSIM bug bounty activity

CMVM 3.4: Operate a bug bounty program

The organization solicits vulnerability reports from external researchers and pays a bounty for each verified and accepted vulnerability received. Payouts typically follow a sliding scale linked to multiple factors, such as vulnerability type (e.g., remote code execution is worth $10,000 versus CSRF is worth $750), exploitability (demonstrable exploits command much higher payouts), or specific services and software versions (widely-deployed or critical services warrant higher payouts). Ad hoc or short-duration activities, such as capture-the-flag contests, do not count.

Outline

Review questions

Server vulnerabilities

- Explain why services running on Unix systems should be robust against both local and remote attackers, even if local users are trusted.

Patches, updates, defences

- Explain the lifecycle of a software vulnerability. Consider cases where the vulnerability is found by a "black-hat" by a "white-hat" first.

Software security processes

- Explain *vendor security advisories* and CVEs.
- Discuss the role of **BSIMM** in improving software security development practices in industry and give example activites in each of its 12 practices.

Next time

Next time we'll start looking at some **overflow vulnerabilities** in more detail.