Web Application Defense with Bayesian Attack Analysis

Presented by:

Ryan Barnett

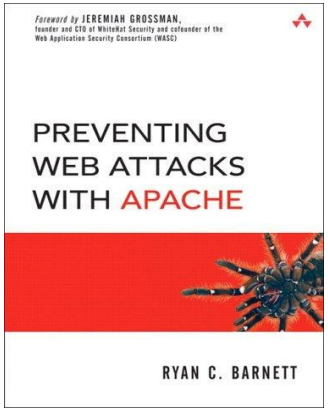
Senior Security Researcher

OWASP ModSecurity CRS Leader

Ryan Barnett - Background

- Trustwave
  - Senior Security Researcher
  - Member of SpiderLabs Research
  - Surveillance Team Lead
    - IDS/IPS
    - MailMax
    - WAF
  - Web Application Defense
  - ModSecurity Project Leader

- Author
  - "Preventing Web Attacks with Apache"
    - Pearson Publishing - 2006
  - "The Web Application Defenders' Cookbook"
    - Wiley Publishing – (Due end of 2012)



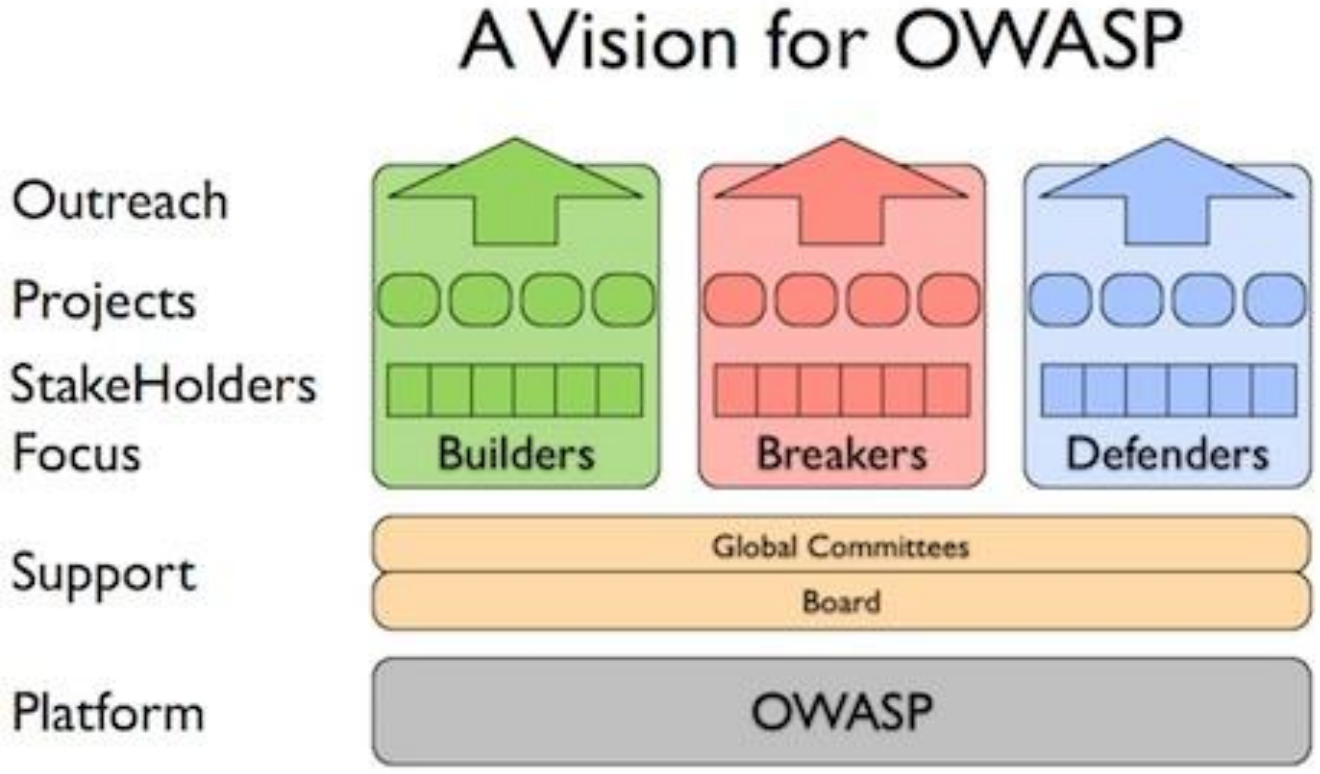
Trustwave SpiderLabs

Trustwave®

Agenda

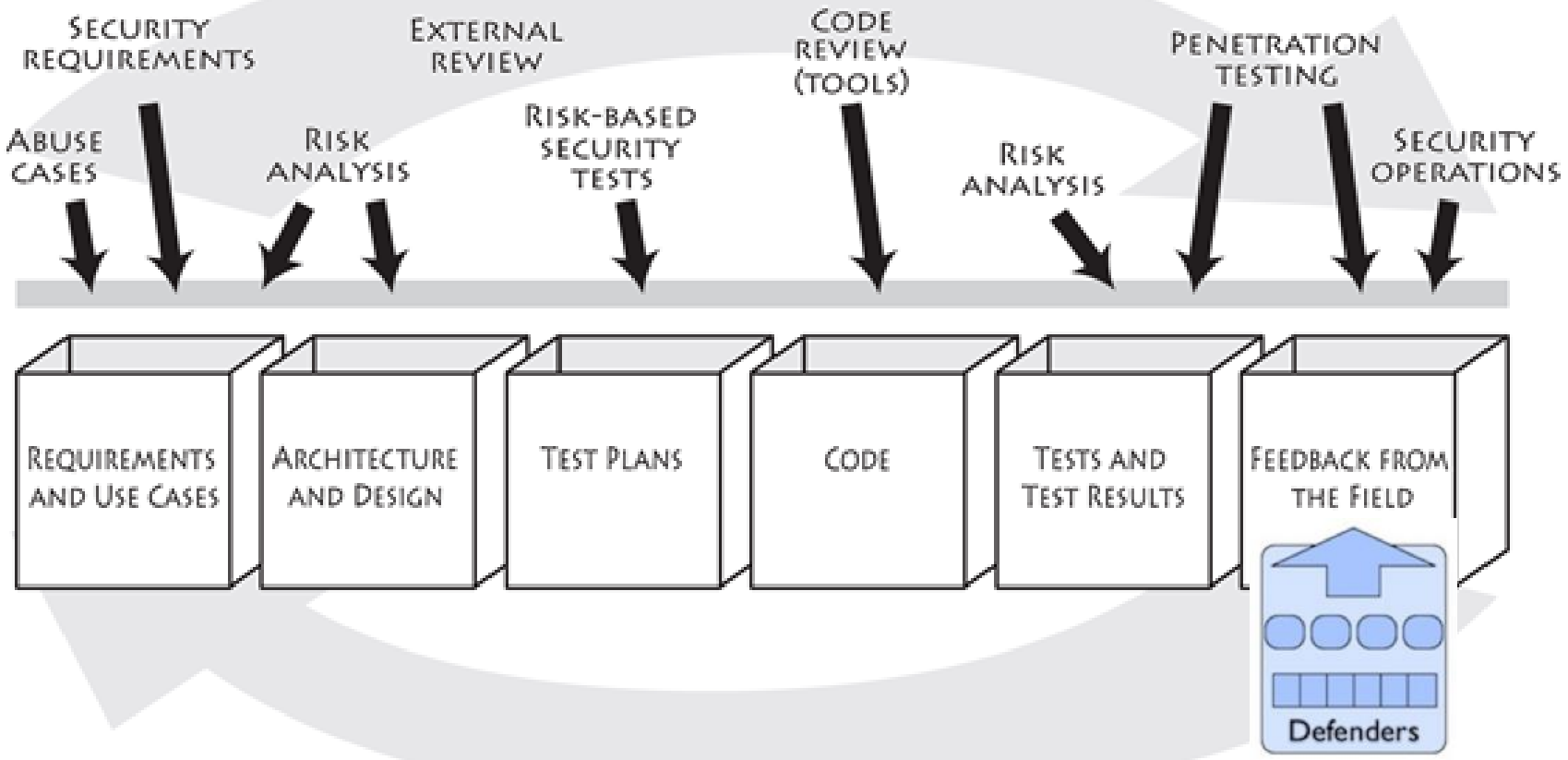
- Attack Resistance Testing
  - Blacklist Filter Evasions
  - ModSecurity SQL Injection Challenge Result Example
- Evasion Analysis
  - Time-to-Hack Metrics
  - Common Evasion Methodology
- Using Bayesian Analysis for Attack Detection
  - OSBF-Lua within ModSecurity
  - Ham/SPAM Training
  - Attack Detection Examples
- Conclusion
  - Development Plans
  - Call for participation

Target Audience: Defender Community



https://www.owasp.org/index.php/Defenders

Defending Live Web Applications



Trustwave SpiderLabs

http://www.swsec.com/resources/touchpoints/

Trustwave®

Tuesday, April 3, 2012

OWASP Security Blitz - April : Injection Attacks

OWASP is starting a monthly security blitz where we will rally the security community around a particular topic. The topic may be a vulnerability, defensive design approach, technology or even a methodology. All members of the security community are encouraged to write blog posts, articles, patches to tools, videos etc in the spirit of the current monthly topic. Our goal is to show a variety of perspectives on the topic from the different perspectives of builders, breakers and defenders.

Today I'm happy to kick off our first month of the OWASP Security Blitz with the topic of:
Injection Attacks - SQL Injection

Please tweet your contributions with **hashtag #OWASP** and also add a **comment to this post** with a link to the material.

At the end of the month we will gather the new articles and include a summary in an upcoming OWASP newsletter. We may even hold a small vote to determine the best contribution of the month.

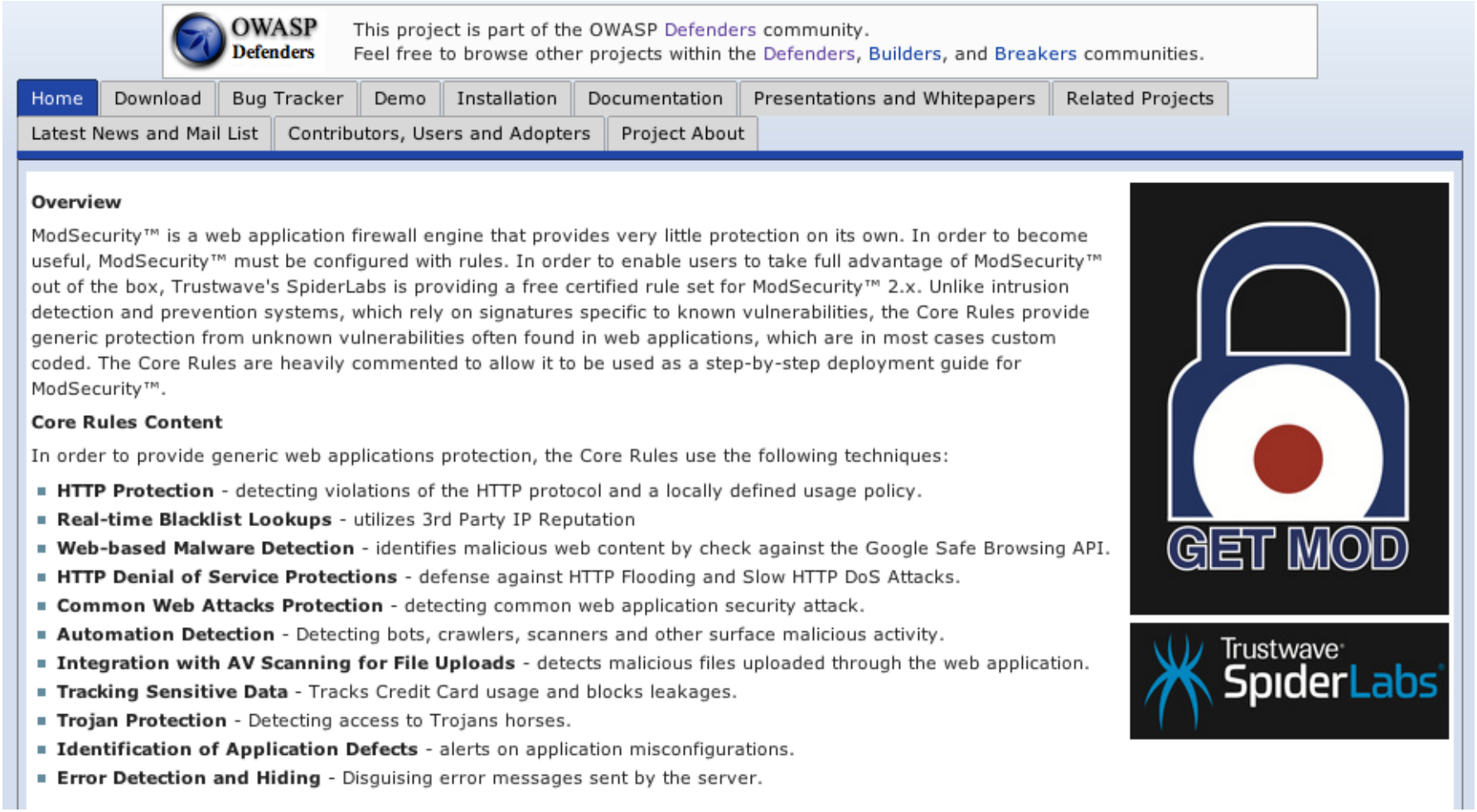
Let's start the rally!

Attack Resistance Testing:
Blacklist Filter Evasions

Trustwave SpiderLabs

Trustwave

OWASP ModSecurity Core Rule Set Project



Trustwave SpiderLabs

http://www.owasp.org/index.php/Category:OWASP_ModSecurity_Core_Rule_Set_Project

Trustwave®

Search

Search

SpiderLabs Services

- 360 Application Security
- App Code Review
- App PenTesting
- Incident Response
- Net PenTesting
- ModSecurity Rules
- Physical Security

Resources

- Advisories
- Papers
- Projects
- Security Tools

Categories

[Honeypot Alert] Advisories
Application Security
Conferences Global Security

« ModSecurity Advanced Topic of the Week: Application Logout Response Actions | Main | Announcing Release of ModSecurity v2.6.1-RC1 »

22 June 2011

Announcing the ModSecurity SQL Injection Challenge

The ModSecurity Project Team is happy to announce our first community hacking challenge!

This is a **SQL Injection and Filter Evasion Challenge**. We have setup ModSecurity to proxy to the following 4 commercial vuln scanner demo sites:

- IBM (AppScan) - demo.testfire.net site
- Cenzic (HailStorm) - CrackMe Bank site
- HP (WebInspect) - Free Bank site
- Acunetix (Acunetix) - Acuart site

Challenge Details

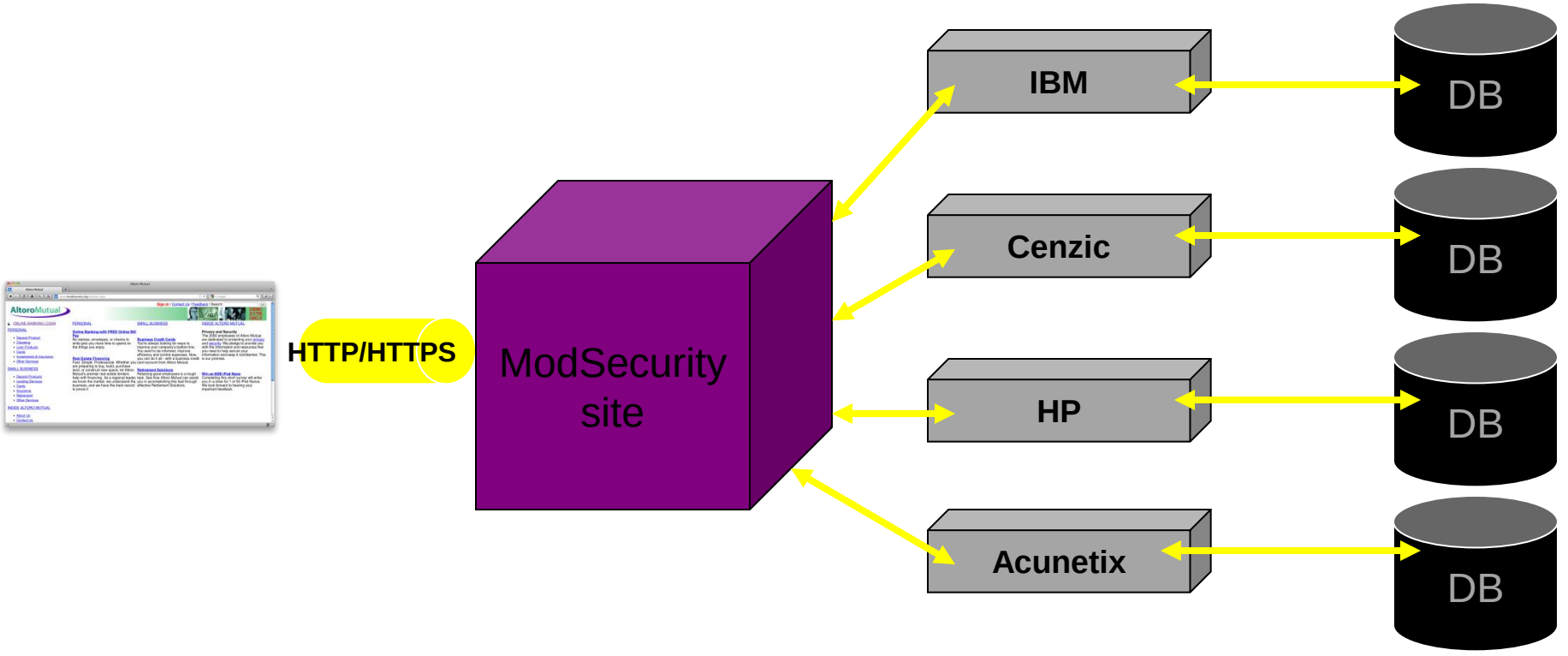
To successfully complete the challenge, participants must do the following:

1. Identify a SQL Injection vector within one of the demo websites listed above.
2. Successfully enumerate the following information about the database:
    - DB User(s) - provide request data.
    - DB Name(s) - provide request data.
    - Table Name(s) - provide request data.
    - Column Name(s) - provide request data.

Challenge Submission

Please send challenge submissions to security@modsecurity.org with the details from above.

SQL Injection Challenge Architecture



Trustwave SpiderLabs

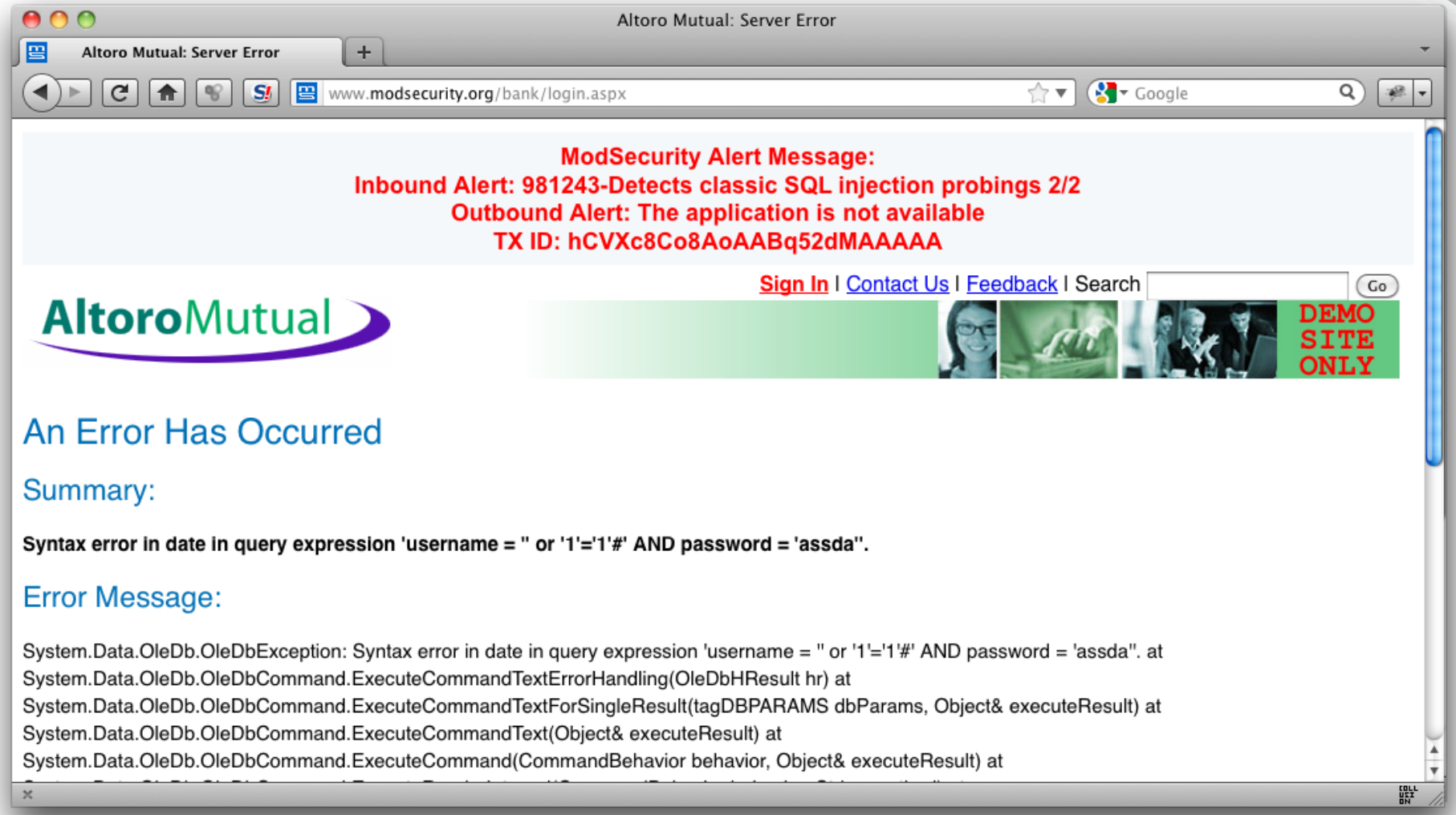
Trustwave®

Two Challenge Levels

- Level I – Speed Hacking
  - Find an SQLi attack vector
  - Exploit the SQLi vulnerability
  - Enumerate the required DB data
  - Submit the data to us for review

- Level II – Blacklist Filter Evasion
  - Same as Level I, however you must evade the OWASP ModSecurity CRS Blacklist Filters

Level II – Filter Evasions



Trustwave SpiderLabs

Trustwave®

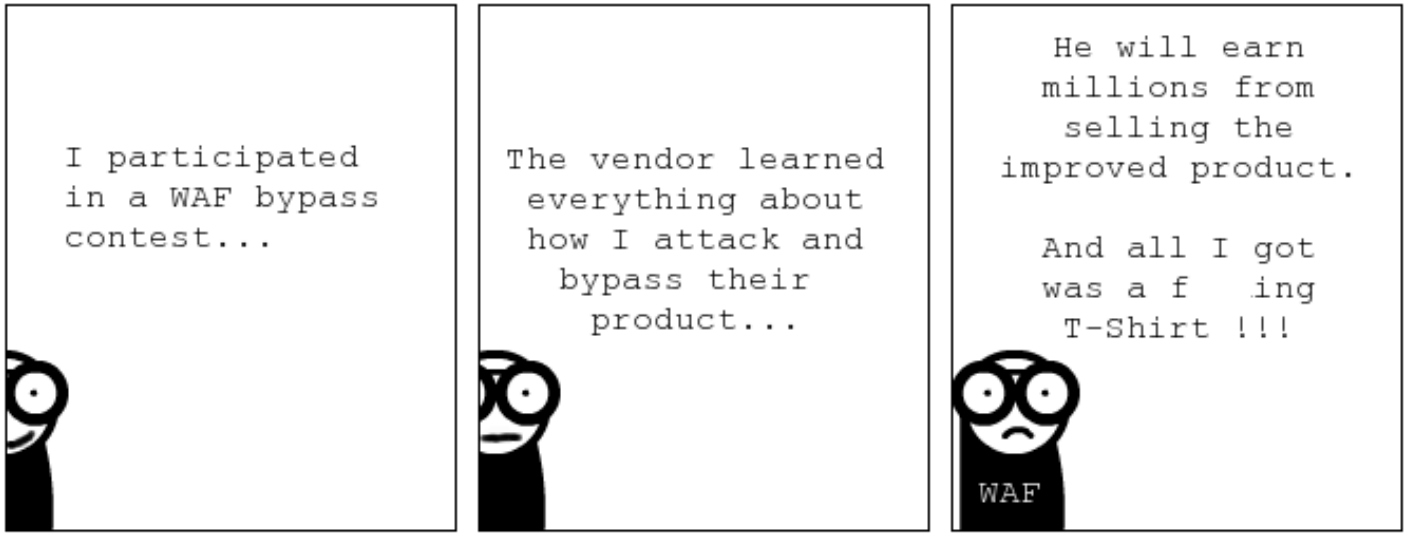
Challenge Participation

- More than 650 participants (in 18 Countries)

http://www.modsecurity.org/demo/challenge.html

Challenge Winners

- Winners received the following:
  - Recognition - Name(s) listed on the Challenge website
  - Shwag - ModSecurity t-shirt
- Everyone is Happy ☺



- Well, almost everyone…

Level 1 Winners

IBM Testfire:

- PT Research

Cenzic CrackMe Bank:

- Ahmad Maulana

HP Free Bank:

- Alexander Zaitsev

Acunetix Acuart:

- Travis Lee

Level 2 Winners

- Johannes Dahse
- Vladimir Vorontsov
- PT Research
- Ahmad Maulana
- Travis Lee
- Roberto Salgado
- SQLMap Developers
- HackPlayers
- Georgi Geshev
- TBD
- TBD
- TBD

Trustwave SpiderLabs

Trustwave®

Level II Filter Evasion:
Example

Attacking the RegEx Logic

```
SecRule REQUEST_FILENAME|ARGS_NAMES|ARGS|XML:/* \
"\bunion\b.{1,100}?\bselect\b" \
"phase:2,rev:'2    ',capture,t:none,t:urlDecodeUni,t:html
EntityDecode,t:l      se
t:replaceCom                                  e,ctl:auditLogParts=
+E,block,msg
Attack',id:'                                  QL_INJECTION',tag:'W
ASCTC/WASC-
19',tag:'OWASP_TOP_10/A1',tag:'OWASP_AppSensor/CIE1',tag:
'PCI/6.5.2',logdata:'%{TX.0}',severity:'2',setvar:'tx.msg
=%{rule.msg}',setvar:tx.sql_injection_score=+%{tx.critica
l_anomaly_score},setvar:tx.anomaly_score=+%{tx.critical_a
nomaly_score},setvar:tx.%{rule.id}-
WEB_ATTACK/SQL_INJECTION-%{matched_var_name}=%{tx.0}"
```

Regex allows up to 100 characters between "union" and "select"

Trustwave SpiderLabs

Trustwave®

8.6. Comment Syntax

MySQL Server supports three comment styles:

- From a "#" character to the end of the line.
- From a "-- " sequence to the end of the line. In MySQL, the "-- " (double-dash) comment style requires the second dash to be followed by at least one whitespace or control character (such as a space, tab, newline, and so on). This syntax differs slightly from standard SQL comment syntax, as discussed in Section 1.8.5.5, "'--' as the Start of a Comment".
- From a /* sequence to the following */ sequence, as in the C programming language. This syntax enables a comment to extend over multiple lines because the beginning and closing sequences need not be on the same line.

The following example demonstrates all three comment styles:

```
mysql> SELECT 1+1;     # This comment continues to the end of line
mysql> SELECT 1+1;     -- This comment continues to the end of line
mysql> SELECT 1 /* this is an in-line comment */ + 1;
mysql> SELECT 1+
/*
this is a
multiple-line comment
*/
1;
```

Nested comments are not supported. (Under some conditions, nested comments might be permitted, but usually are not, and users should avoid them.)

Excessive Comment Text

- %40%40new%20union%23sqlmapsql%0Aselect%201,2,database%23sqlmap%0A%28%29

- URL Decoded
- @@new union#sqlmapsqlmapsq[illegible]mapsqlmapsqlmapsqlmapsqlmapsqlmapsqlmapsqlmapsqlmapsqlmapsqlmapsqlmapsqlmapsql\nselect 1,2,database#sqlmap\n()

103 chars of random text bypasses the regex rule logic

Evasion Analysis

Common Methodology

- Automation to identify injection points
  - NetSparker
  - Arachni
  - Sqlmap
  - Havij

- Manual testing to develop working SQLi payloads
  - ***An iterative process of trial and error***

1. Send initial payloads and observe DB responses
2. Use obfuscation tactics (comments, encodings, etc…)
3. Send payload and observe DB response
4. Repeat steps 2 - 3

Iterative Testing Example

div 1 union%23%0Aselect 1,2,current_user

div 1 union%23foo*/*bar%0Aselect 1,2,current_user

div 1 union%23foofoofoofoo*/*bar%0Aselect 1,2,current_user

div 1 union%23foofoofoofoofoofoofoofoofoofoo*/*bar%0Aselect 1,2,current_user

…

div 1 union**%23foofoofoofoofoofoofoofoofoofoofoofoofoofoofoofoofoofoofoofoofoofoofoofoofoofoofoofoofoo*/*bar%0A**select 1,2,current_user

Time-to-Hack Metrics

Time-to-Hack Metric	Speed Hacking	Filter Evasion
Avg. # of Requests	170	433
Avg. Duration (Time)	5 hrs 23 mins	72 hrs
Shortest # of Requests	36	118
Shortest Duration (Time)	46 mins	10 hrs

Filter Evasion Conclusions

- Blacklist filtering will only slow down determined attackers
- Attackers need to try ***many permutations*** to identify a working filter evasion
- The OWASP ModSecurity Core Rules Set's blacklists SQLi signatures ***caught several hundred*** attempts before an evasion was found

Questions

- How can we use this methodology to our advantage?
- What detection technique can we use other than regular expressions?

Application Intrusion Detection

- Positive/Whitelist Security Model Input Validation
  - Allowed characters
  - Length
  - WAF Traffic Profiling
- Response Time Latency Tracking
  - Deviations of response data due to blind SQLi queries (waitfor delay, benchmark() or pg_sleep)
- Response Page Fingerprint Deviations
  - Changes to the page construction (title, size, etc…)
  - Deviation in the amount of sensitive records returned

Using Bayesian Analysis for Attack Detection

Trustwave SpiderLabs

Trustwave

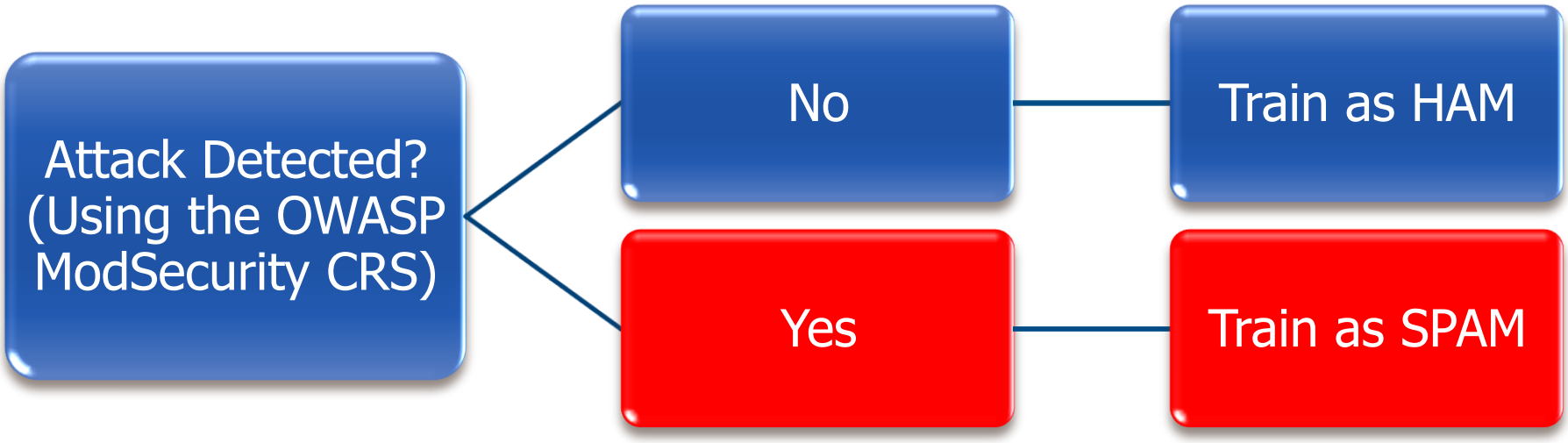
Bayesian Analysis for HTTP

- RegEx detection is binary
  - The operator either matched or it didn't
  - Need a method of detecting ***attack probability***
- Bayesian analysis has achieved great results in Anti-SPAM efforts for email
- Can't we use the same detection logic for HTTP data?
  - Data Source
    - Email – OS level text files
    - HTTP – text taken directly from HTTP transaction
  - Data Format
    - Email – Mime headers + Email body
    - HTTP – URI + Request Headers + Parameters
  - Data Classification
    - Non-malicious HTTP request = HAM
    - HTTP Attack payloads = SPAM

OSBF-Lua

- OSBF-Lua by Fidelis Assis
  - Orthogonal Sparse Bigrams with Confidence Factor (OSBF)
  - Uses space characters for tokenization (which means that it factors in meta-characters)
  - Very fast
  - Accurate classifiers
  - http://osbf-lua.luaforge.net/
- Moonfilter by Christian Siefkes
  - Wrapper script for OSBF
  - http://www.siefkes.net/software/moonfilter/
- Integrate with ModSecurity's Lua API

Training the OSBF Classifiers



Theory of Operation - HAM

1. Non-malicious user data does not trigger any blacklist rules
2. Lua script trains OSBF classifier that payloads are HAM

Lua: Executing script: /etc/httpd/modsecurity.d/bayes_train_ham.lua
Arg Name: ARGS:txtFirstName and Arg Value: Bob.
Arg Name: ARGS:txtLastName and Arg Value: Smith.
Arg Name: ARGS:txtSocialScurityNo and Arg Value: 123-12-9045.
Arg Name: ARGS:txtDOB and Arg Value: 1958-12-12.
Arg Name: ARGS:txtAddress and Arg Value: 123 Someplace Dr..
Arg Name: ARGS:txtCity and Arg Value: Fairfax.
Arg Name: ARGS:drpState and Arg Value: VA.
Arg Name: ARGS:txtTelephoneNo and Arg Value: 703-794-2222.
Arg Name: ARGS:txtEmail and Arg Value: bob.smith@mail.com.
Arg Name: ARGS:txtAnnualIncome and Arg Value: $90,000.
Arg Name: ARGS:drpLoanType and Arg Value: Car.
Arg Name: ARGS:sendbutton1 and Arg Value: Submit.
Low Bayesian Score: . Training payloads as non-malicious.

Theory of Operation - SPAM

1. Attacker sends malicious payloads during initial testing phase
2. Payloads are caught by our blacklist rules
3. Lua script trains OSBF classifier that payloads are SPAM

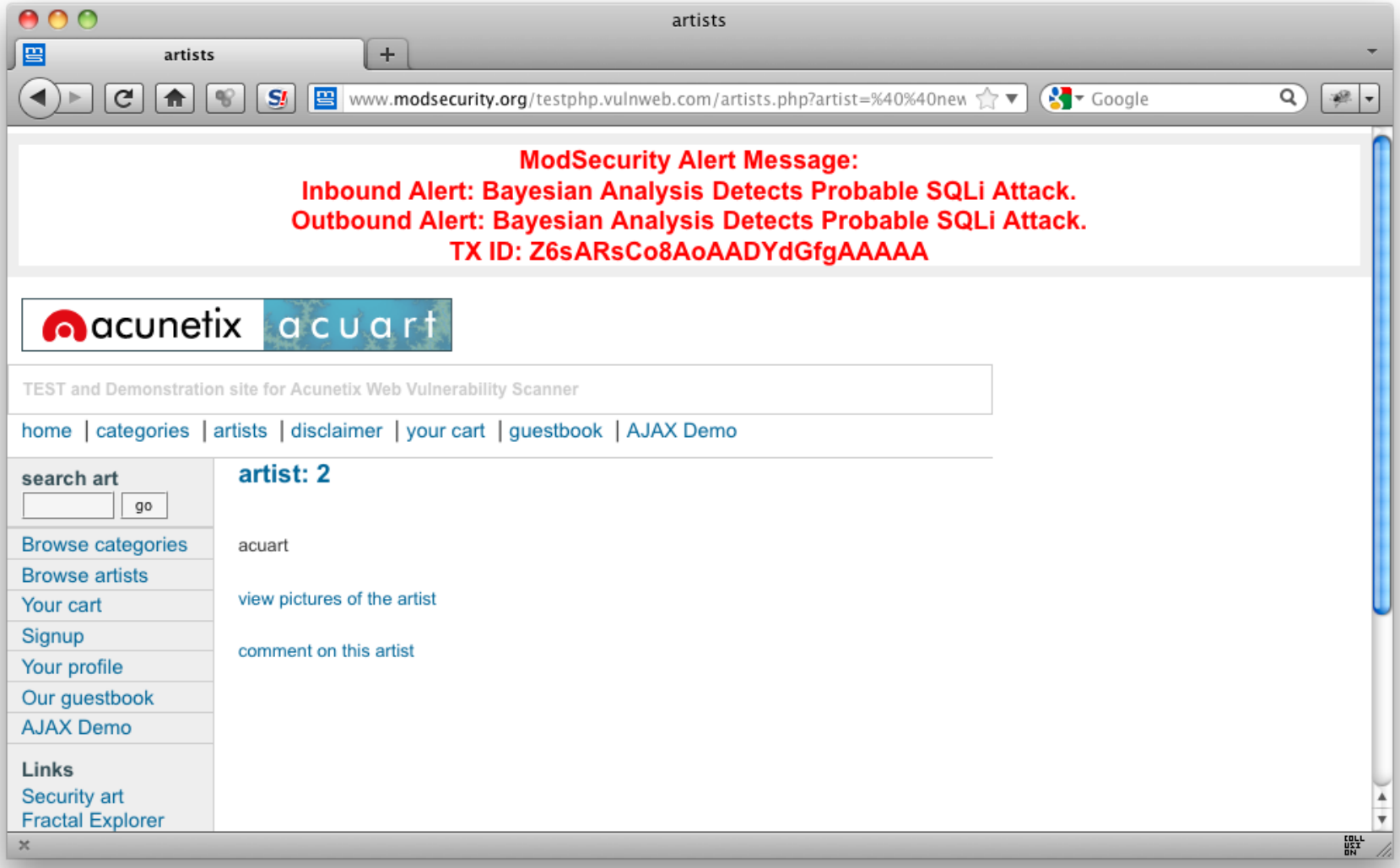
```
[Thu Nov 03 15:21:08 2011] [error] [client
72.192.214.223] ModSecurity: Warning. Pattern match
".*" at TX:981231-WEB_ATTACK/SQL_INJECTION-
ARGS:artist. [file
"/etc/httpd/modsecurity.d/crs/base_rules/modsecurity_c
rs_48_bayes_analysis.conf"] [line "1"] [data
"Completed Bayesian Training on SQLi Payload: @@new
union#sqlmapsqlmapsqlmapsqlmapsqlmapsqlmapsqlmapsqlmapsqlmap
sqlmapsqlmapsqlmapsqlmapsqlmapsqlmapsqlmapsqlmapsqlmapsql\\x
0aselect 1,2,database#sqlmap\\x0a()."] [hostname
"www.modsecurity.org"] [uri
"/testphp.vulnweb.com/artists.php"] [unique_id
"VCqlxsCo8AoAADYJV3kAAAAH"]
```

Theory of Operation - Unknown

- Previous evasion payload is now caught

```
[Thu Nov 03 15:28:18 2011] [error] [client 72.192.214.223]
ModSecurity: Warning. Bayesian Analysis Alert for
ARGS:artist with payload: "@@new
union#sqlmapsqlmapsqlmapsqlmapsqlmapsqlmapsqlmapsqlmapsqlmapsqlmap
sqlmapsqlmapsqlmapsqlmapsqlmapsqlmapsqlmapsqlmapsql\nselect
1,2,database#sqlmap\n()" [file
"/etc/httpd/modsecurity.d/crs/base_rules/modsecurity_crs_48_
bayes_analysis.conf"] [line "3"] [msg "Bayesian Analysis
Detects Probable SQLi Attack."] [data "Score:
{prob=0.99999999965698,probs={0.99999999965698,3.43018986145
48e-
10},class=\\x22/var/log/httpd/spam\\x22,pR=5.5841622861233,r
einforce=true}"] [severity "CRITICAL"] [tag
"WEB_ATTACK/SQL_INJECTION"] [tag "WASCTC/WASC-19"] [tag
"OWASP_TOP_10/A1"] [tag "OWASP_AppSensor/CIE1"] [tag
"PCI/6.5.2"] [hostname "www.modsecurity.org"] [uri
"/testphp.vulnweb.com/artists.php"] [unique_id
"bcjElMCo8AoAADYlSXMAAAAI"]
```

Bayesian Alert for Evasion Payload



Trustwave SpiderLabs

Trustwave®

Conclusion

Development Plans/Call for Assistance

- This proof of concept will eventually be put into the OWASP ModSecurity CRS
  - Other projects may consider using it too (AppSensor, ESAPI, etc…)
- Need to include HTTP Header data in training
  - For accurate Bayesian classification, more data is better.
  - Including HTTP Header data may also help to identify non-browser/tool attacks
- Need more testing
  - If you would like to help with testing, please contact me and I will provide you access to the Lua scripts.

ModSecurity T-Shirt Giveaway

- What was the shortest "Time-to-Evasion" from Level II?
- 10 hrs.

Contact/Resources

- Email
  - OWASP: ryan.barnett@owasp.org
  - Trustwave: rbarnett@trustwave.com
- Twitter
  - @ryancbarnett
  - @ModSecurity
  - @SpiderLabs
- Blog
  - http://tacticalwebappsec.blogspot.com
  - http://blog.spiderlabs.com

Trustwave SpiderLabs

Trustwave®