ModProfiler: Defending Web Applications from 0-day Attacks

Signatures out. Traffic profiling in.

Ivan Ristić and Ofer Shezaf

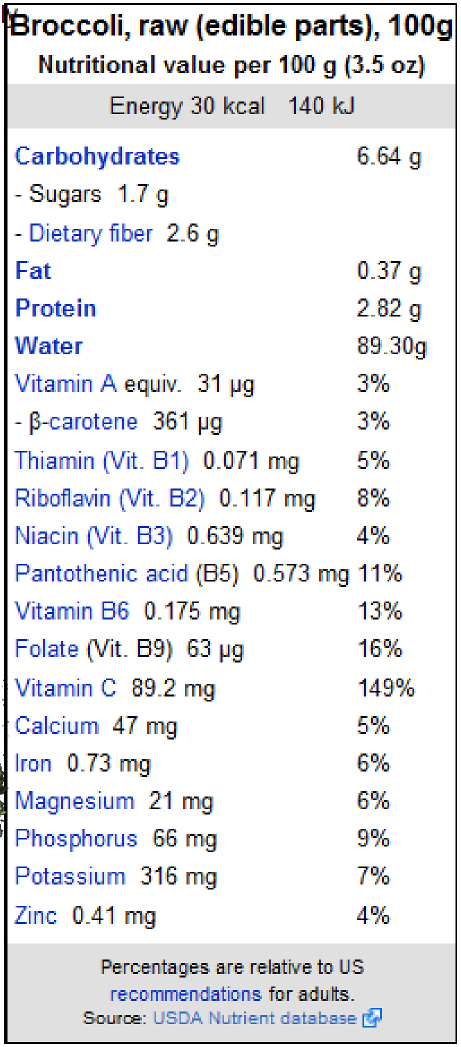
Breach Security

OWASP Israel 2008

Broccoli is good for your health…

“Broccoli is a plant of the Cabbage family, Brassicaceae (formerly Cruciferae). It is classified as the Italica Cultivar Group of the species Brassica oleracea. Broccoli possesses abundant fleshy flower heads….”

Wikipedia



Broccoli, raw (edible parts), 100g

Nutritional value per 100 g (3.5 oz)

Energy 30 kcal 140 kJ

Carbohydrates	6.64 g
- Sugars 1.7 g	
- Dietary fiber 2.6 g	
Fat	0.37 g
Protein	2.82 g
Water	89.30g
Vitamin A equiv. 31 μg	3%
- β-carotene 361 μg	3%
Thiamin (Vit. B1) 0.071 mg	5%
Riboflavin (Vit. B2) 0.117 mg	8%
Niacin (Vit. B3) 0.639 mg	4%
Pantothenic acid (B5) 0.573 mg	11%
Vitamin B6 0.175 mg	13%
Folate (Vit. B9) 63 μg	16%
Vitamin C 89.2 mg	149%
Calcium 47 mg	5%
Iron 0.73 mg	6%
Magnesium 21 mg	6%
Phosphorus 66 mg	9%
Potassium 316 mg	7%
Zinc 0.41 mg	4%

Percentages are relative to US recommendations for adults.
Source: USDA Nutrient database

About Us

Ivan Ristić and Ofer Shezaf, Breach Security

- Web application firewall experts:
  - Ivan created ModSecurity, the most popular WAF on earth, and wrote “Apache Security” for O’Reilly.
  - Ofer created WebDefend, the first and most advanced behavioral based WAF.
- Web application security leaders:
  - Officers of the Web Application Security Consortium (WASC).
  - Lead OWASP chapters in London and Israel.
- Open source and community projects:
  - Ivan leads the WASC Web Application Firewall Evaluation Criteria (WAFEC).
  - Ofer leads the WASC Web Hacking Incidents Database (WHID) project.

Breach Security

Technology Leaders

- Breach is a leading WAF vendor.
- Sole focus on web application security since 1999.
- Managed by a group of experienced security professionals.
- Best application security DNA in the industry. We write the books.
- Home to ModSecurity, the open source WAF.

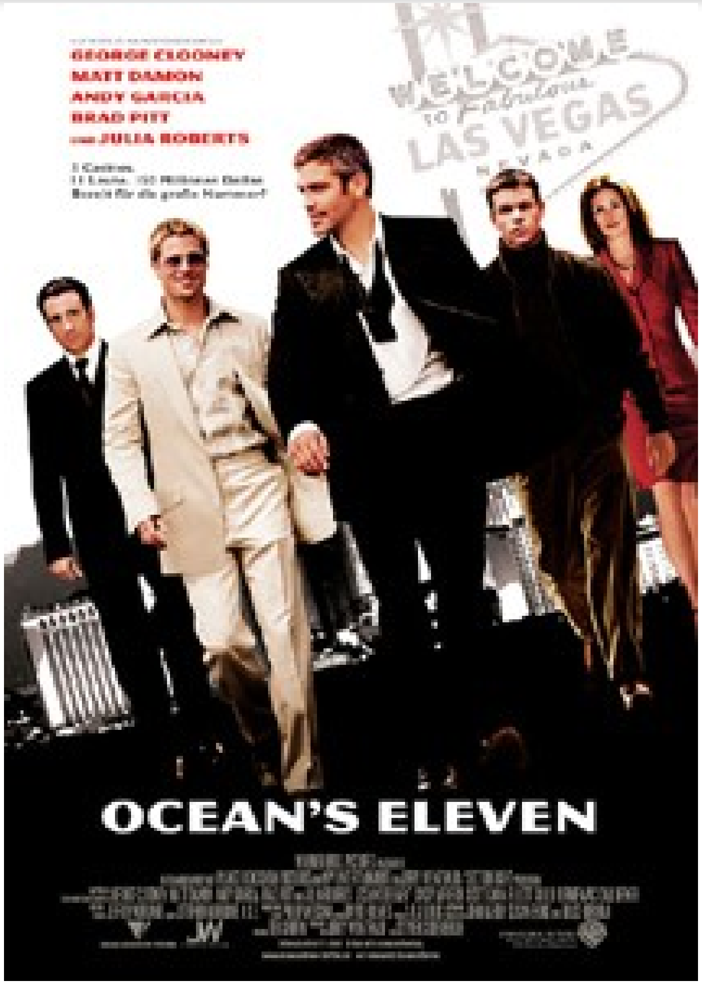
The Complete Guide to Securing Your Apache Web Server
Apache Security
Ivan Ristic
Foreword by JEREMIAH GROSSMAN
PREVENTING WEB ATTACKS WITH APACHE
RYAN C. BARNETT

APPETIZER

THE PROBLEM DOMAIN

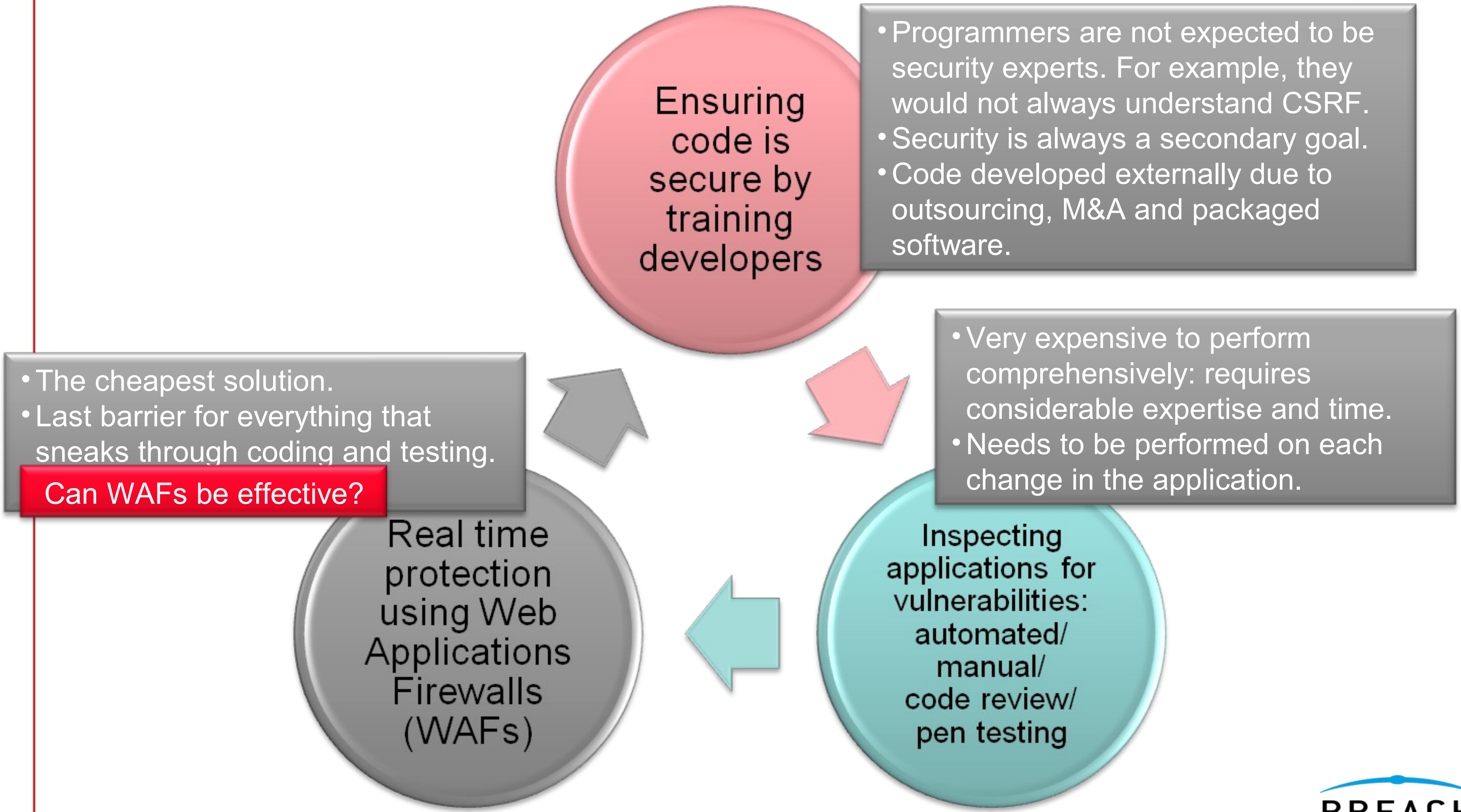
Web Applications Are Dangerous

- Applications are ***vulnerable***:
  - Unique, each one exposing its own vulnerabilities.
  - Change frequently, requiring constant tuning of application security.
  - Complex and feature rich with the advent of AJAX, Web Services and Web 2.0.
- Applications are ***under threat***:
  - New business models drive “for profit” hacking.
  - Performed by professionals enabling complex attacks.
- Potential ***impact*** may be severe:
  - Web applications are used for sensitive information and important transactions.
  - Attack may target site customers.


GEORGE CLOONEY
MATT DAMON
ANDY GARCIA
BRAD PITT
JULIA ROBERTS
3 Casinos.
11 Leute. 150 Millionen Dollar.
Bereit für die große Nummer?
WELCOME to Fabulous LAS VEGAS NEVADA
OCEAN'S ELEVEN

What Are We Doing About It?

Web Application Security through the application lifecycle



Ensuring code is secure by training developers

- Programmers are not expected to be security experts. For example, they would not always understand CSRF.
- Security is always a secondary goal.
- Code developed externally due to outsourcing, M&A and packaged software.

Inspecting applications for vulnerabilities: automated/ manual/ code review/ pen testing

- Very expensive to perform comprehensively: requires considerable expertise and time.
- Needs to be performed on each change in the application.

Real time protection using Web Applications Firewalls (WAFs)

- The cheapest solution.
- Last barrier for everything that sneaks through coding and testing.

Can WAFs be effective?

WAF Protection Strategies

Negative security model: allow all, deny what's wrong

- Web specific IPS.
- Simple concept, generic to all applications and provides instant security.
- Based on rules instead of signatures: full parsing, complex logic, anti-evasion.
- Difficult to guard against every attack variant and evasion attempts.

Positive security model: deny all, allow what's right

- An independent input validation envelope for web applications.
- Provides the best protection.
- Rules must be written specifically for each page in the application.
- Rules needs to be maintained as the application changes.
- Easy to write for specific vulnerabilities (virtual patching)

BREACH SECURITY LABS

Why is Positive Security Better?

- Classic example of an SQL injection attack
  - **1=1**
  - Many IPS solutions include a signature to detect this attack.
- A WAF would easily overcome these evasions:
  - Encoding: **1%3D1**
  - Including white space characters: **1   =%091**
  - Adding SQL inline comments: **1 /* comment */ = 1**
- But it is impossible to create a signature for every tautology:
  - **1+1=2**, **2 > 1** and for some databases just **1**.
- A positive security rule will provide the best security:

```
<Location "/login.php">
    SecRule ARGS:username "!^\w+$" "deny,log"
>/LocationMatch>
```

Where is the Catch?

Positive security models are generally difficult to build and maintain.

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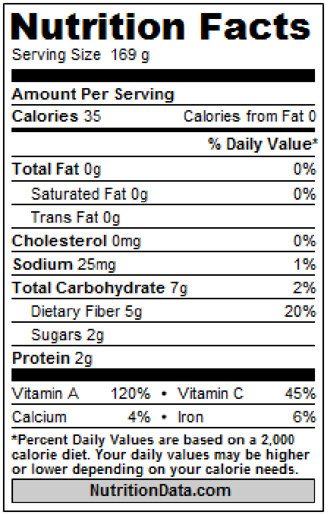
FIRST COURSE

MODSECURITY



Nutrition Facts

Serving Size 169 g

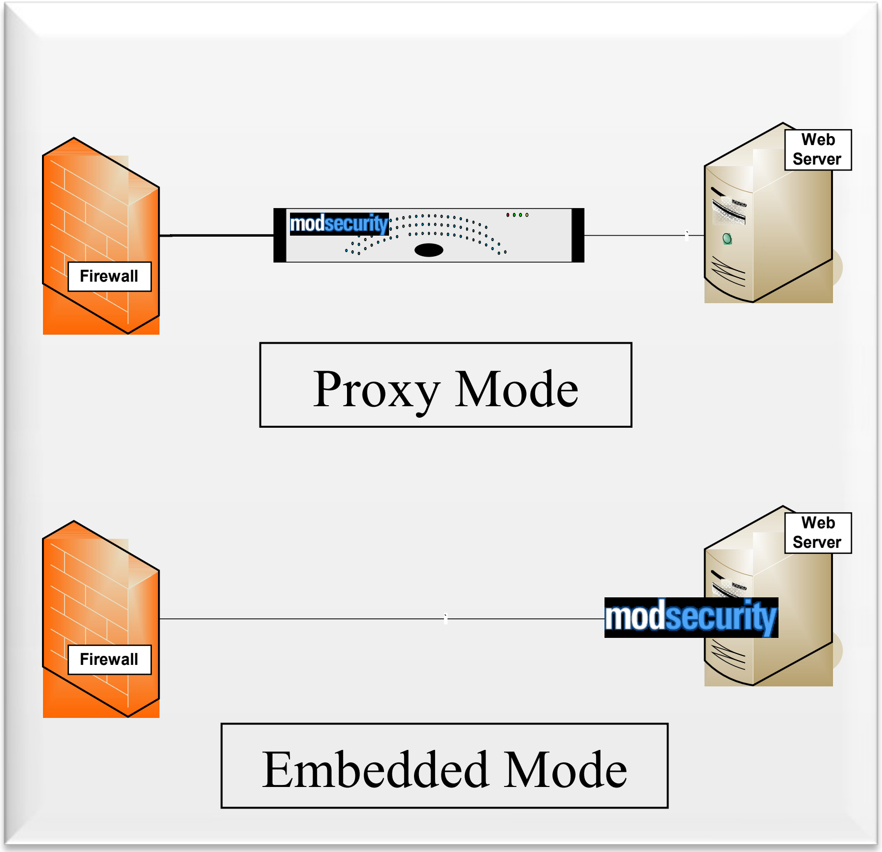
Amount Per Serving	
Calories 35	Calories from Fat 0
	% Daily Value*
Total Fat 0g	0%
Saturated Fat 0g	0%
Trans Fat 0g	
Cholesterol 0mg	0%
Sodium 25mg	1%
Total Carbohydrate 7g	2%
Dietary Fiber 5g	20%
Sugars 2g	
Protein 2g	
Vitamin A 120%	• Vitamin C 45%
Calcium 4%	• Iron 6%

*Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs.

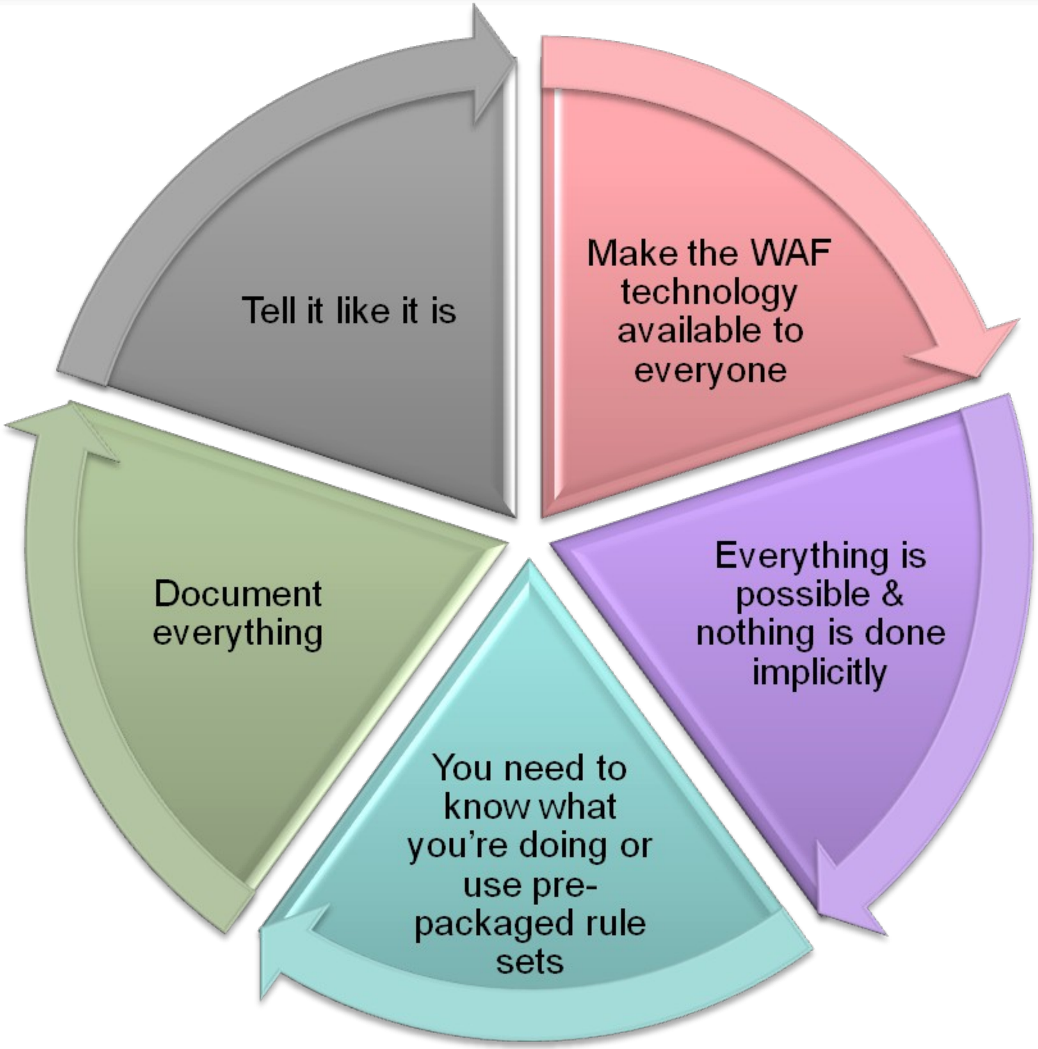
NutritionData.com

What is ModSecurity?

- The most popular WAF in the world with (a lot) more than 10,000 installations.
- An open source production grade project, started in 2002.
- An Apache module which supports both *embedded* and *reverse proxy* deployments.
- Support and training by Breach Security.



ModSecurity Philosophy



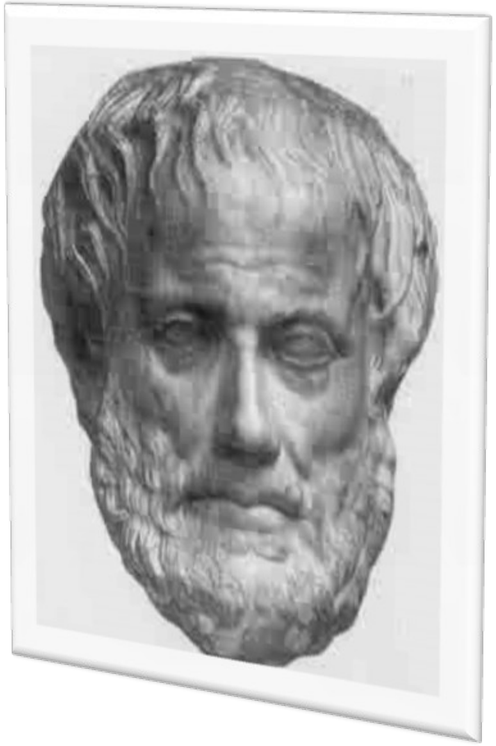
Tell it like it is

Make the WAF technology available to everyone

Everything is possible & nothing is done implicitly

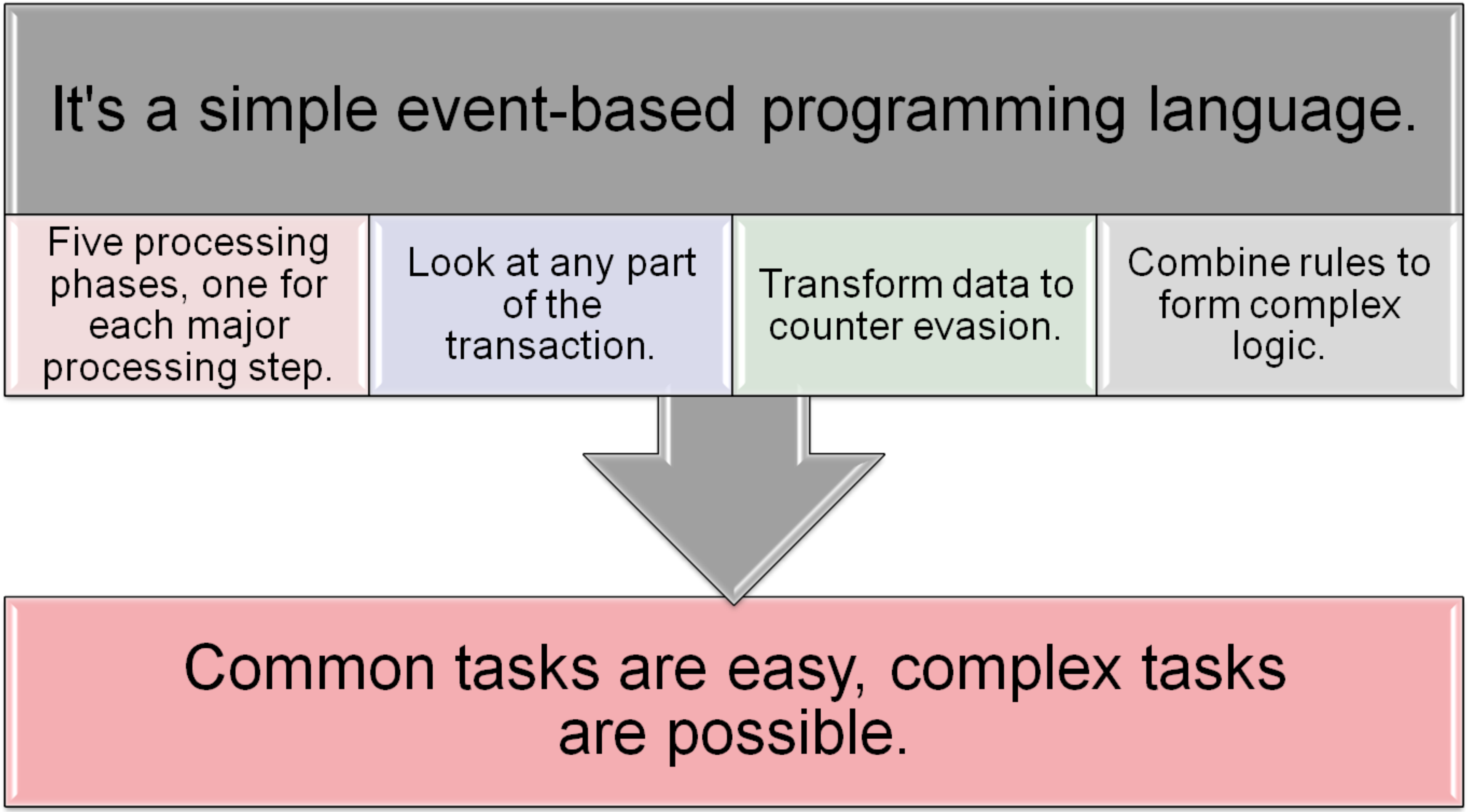
You need to know what you're doing or use pre-packaged rule sets

Document everything



BREACH SECURITY LABS

ModSecurity Rules Language



It's a simple event-based programming language.

Five processing phases, one for each major processing step.

Look at any part of the transaction.

Transform data to counter evasion.

Combine rules to form complex logic.

Common tasks are easy, complex tasks are possible.

Advanced Features

Persist information across requests; You can create small databases of sorts.

Support for anomaly-based rules.

Support for sessions and application users.

Log entire transactions or sessions, sanitize data before logging.

Intercept file uploads.

XML support (parse, validate, extract).

Example Rules

Very simple

- SecRule ARGS attack
- SecRule "ARGS|!ARGS:p" attack

Different operator

- SecRule ARGS "@verifyByteRange 10,13,32-126"

Interesting

- SecRule REMOTE_ADDR "@rbl sc.surbl.org"

Real Life Example

Virtual patching example using the positive security approach:

```
<Location /apps/script.php>
    SecRule &ARGS "!@eq 1"
    SecRule ARGS_NAMES "!^statid$"
    SecRule ARGS:statID "!^\d{1,3}$"
</Location>
```

Rules should include meta-data, such as ID, revision, human-readable message, and so on.

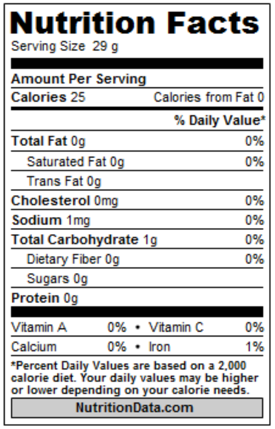
BREACH SECURITY LABS

Components

ModSecurity 2.5	• The core rules processing engine.
ModSecurity Core Rules	• An open source rule set providing a generic negative security application layer protection.
ModSecurity Community Console	• A free GUI tool for aggregating events from up to 3 ModSecurity sensors.
The community	• Glues everything together

HAVE A DRINK

POSITIVE SECURITY THROUGH LEARNING



Nutrition Facts

Serving Size 29 g

Amount Per Serving	
Calories 25	Calories from Fat 0
	% Daily Value*
Total Fat 0g	0%
Saturated Fat 0g	0%
Trans Fat 0g	
Cholesterol 0mg	0%
Sodium 1mg	0%
Total Carbohydrate 1g	0%
Dietary Fiber 0g	0%
Sugars 0g	
Protein 0g	
Vitamin A 0% • Vitamin C	0%
Calcium 0% • Iron	1%

*Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs.

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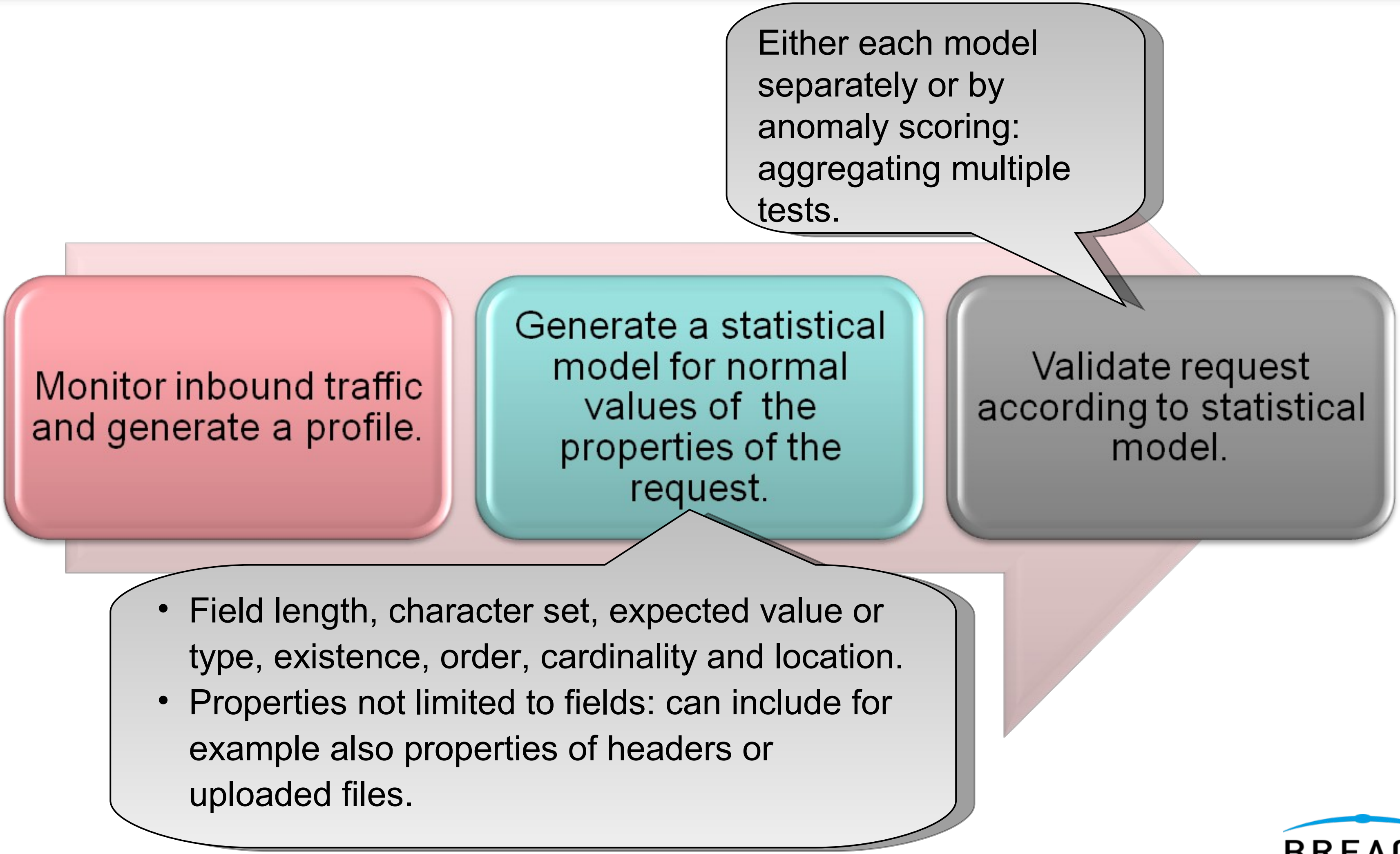
Behavioral-Based Learning



Either each model separately or by anomaly scoring: aggregating multiple tests.

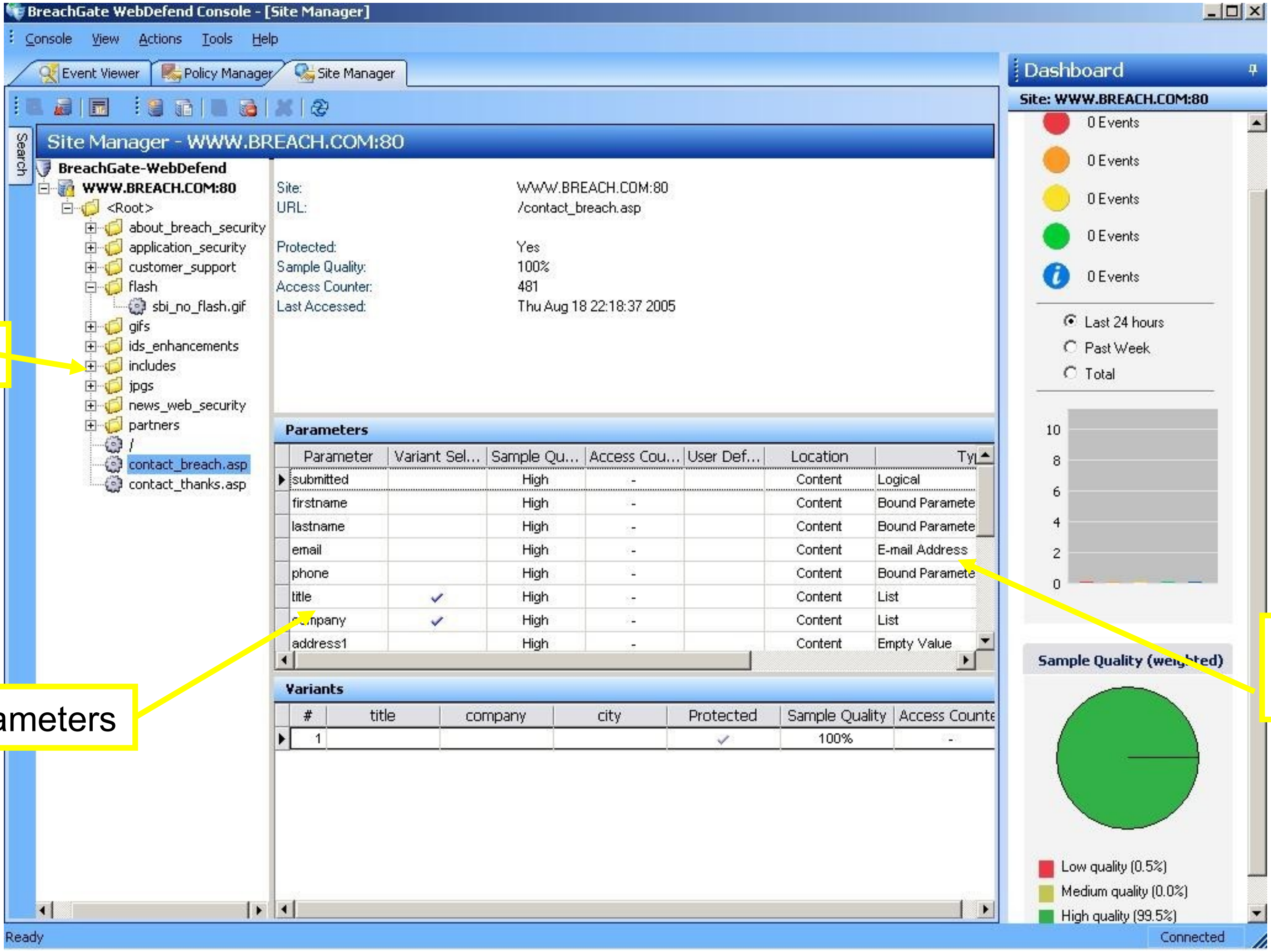
Monitor inbound traffic and generate a profile.

Generate a statistical model for normal values of the properties of the request.

Validate request according to statistical model.

- Field length, character set, expected value or type, existence, order, cardinality and location.
- Properties not limited to fields: can include for example also properties of headers or uploaded files.

Sample Profile



Site Manager - WWW.BREACH.COM:80

- BreachGate-WebDefend
  - WWW.BREACH.COM:80
    - <Root>
      - about_breach_security
      - application_security
      - customer_support
      - flash
        - sbi_no_flash.gif
      - gifs
      - ids_enhancements
      - includes
      - jpgs
      - news_web_security
      - partners
      - /
      - contact_breach.asp
      - contact_thanks.asp

Site:	WWW.BREACH.COM:80
URL:	/contact_breach.asp
Protected:	Yes
Sample Quality:	100%
Access Counter:	481
Last Accessed:	Thu Aug 18 22:18:37 2005

Parameters

Parameter	Variant Sel...	Sample Qu...	Access Cou...	User Def...	Location	Ty
submitted		High	-		Content	Logical
firstname		High	-		Content	Bound Paramete
lastname		High	-		Content	Bound Paramete
email		High	-		Content	E-mail Address
phone		High	-		Content	Bound Paramete
title	✓	High	-		Content	List
company	✓	High	-		Content	List
address1		High	-		Content	Empty Value

Variants

#	title	company	city	Protected	Sample Quality	Access Counte
1				✓	100%	-

Site: WWW.BREACH.COM:80

🔴	0 Events
🟠	0 Events
🟡	0 Events
🟢	0 Events
i	0 Events

● Last 24 hours
○ Past Week
○ Total

Sample Quality (weighted)

🟥 Low quality (0.5%)
🟨 Medium quality (0.0%)
🟩 High quality (99.5%)

Site Map

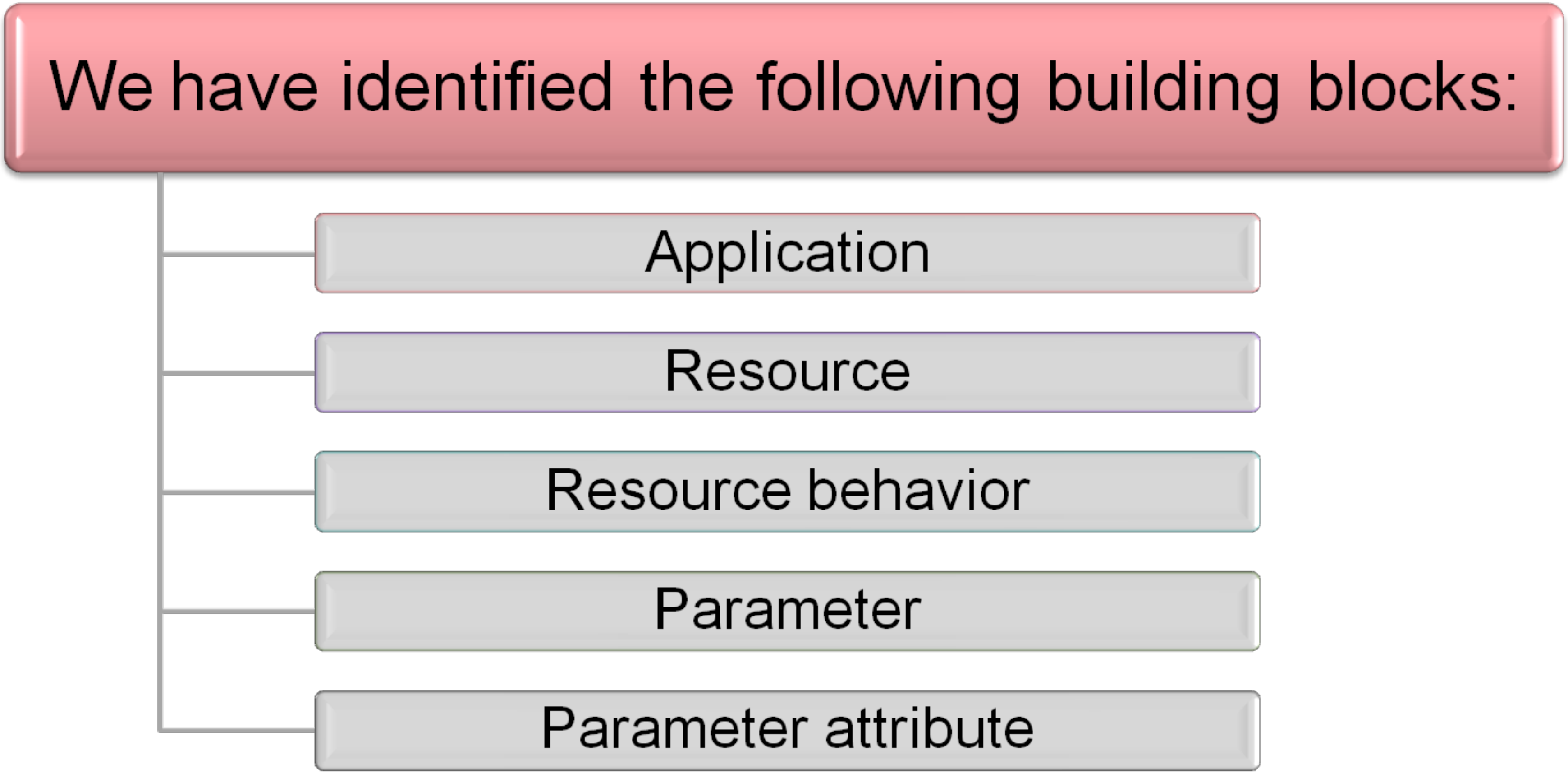
Parameters

Parameter Types

Model Requirements

Portability	• Must work with any web-based application, irrespective of the underlying platform.
Partial model support	• In terms of coverage, but also in terms of quality.
Real-life usefulness	• Must correlate to the attack landscape.
Ease of use	• We want people to be able to write and maintain models by hand.

Model Building Blocks



We have identified the following building blocks:

- Application
- Resource
- Resource behavior
- Parameter
- Parameter attribute

Real-Life Challenges

Data embedded in URLs

- http://www.amazon.com/dp/0596007248/

Default pages (i.e. resource aliases)

- http://example.com the same as http://example.com/index.php

Internal request dispatching

- http://example.com/?cmd=show behaves differently from http://example.com/?cmd=update

Parameters generated at run-time

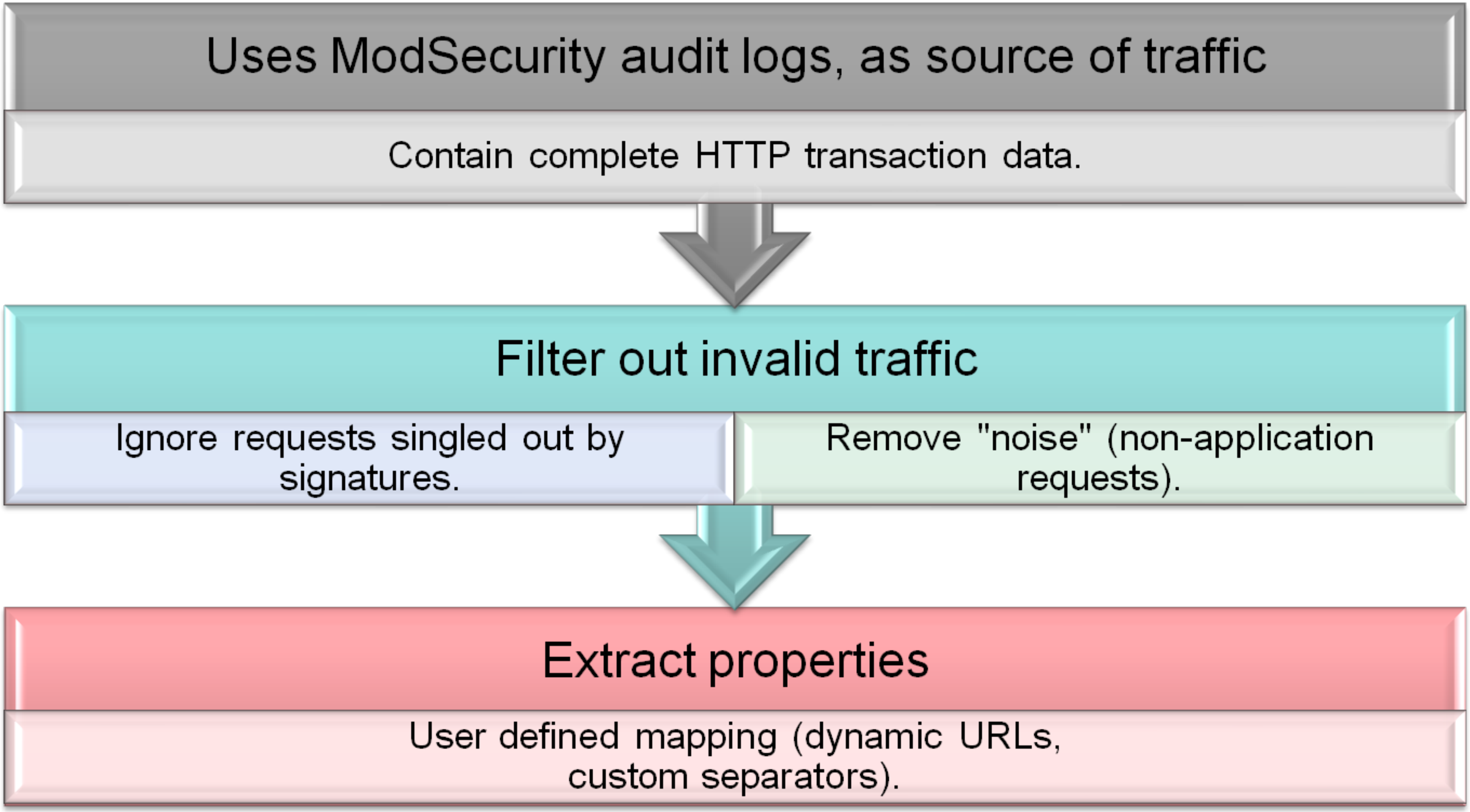
- http://example.com/?a5647=89

Storage Format: More Than Anticipated

Suddenly we realize the storage format for our model is useful for more than profiling through learning:

- Models could be distributed by application developers.
- Users can write and exchange application models.
- Community projects could maintain models as separate projects.
- The same model works well for virtual patching.

Collecting Data



Uses ModSecurity audit logs, as source of traffic

Contain complete HTTP transaction data.

Filter out invalid traffic

Ignore requests singled out by signatures.

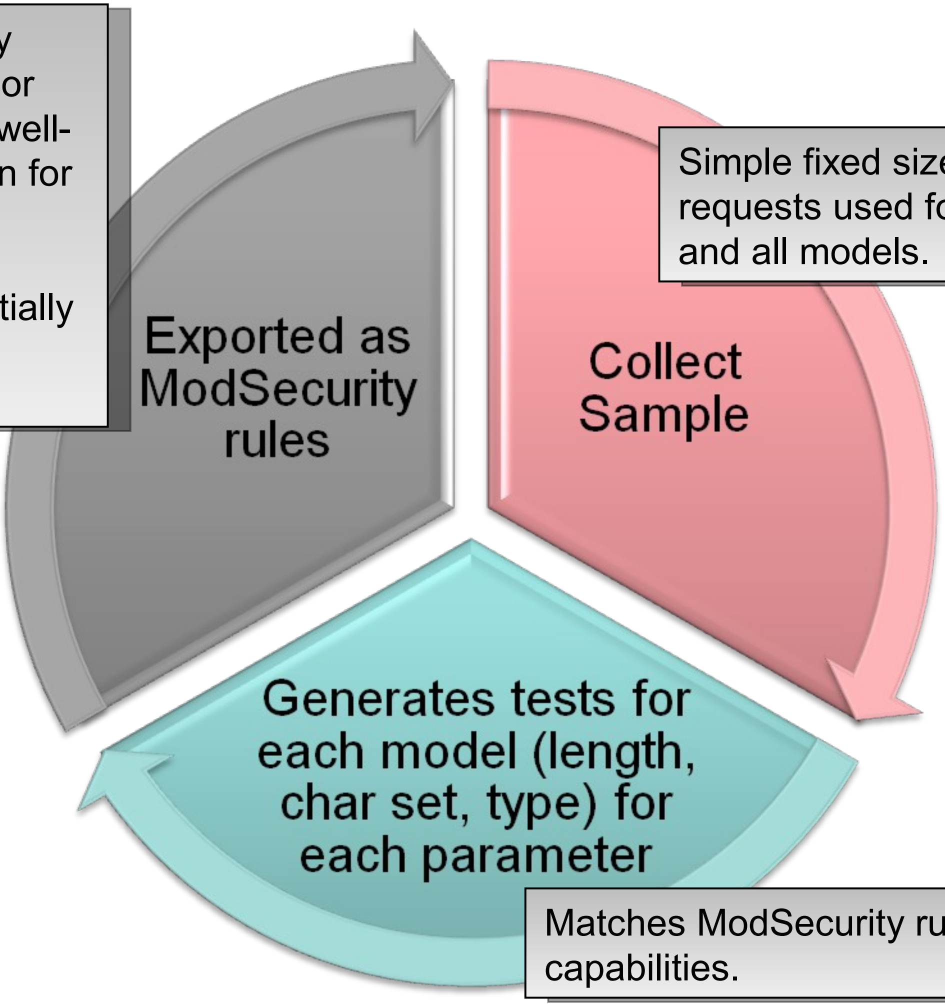
Remove "noise" (non-application requests).

Extract properties

User defined mapping (dynamic URLs, custom separators).

Model Generation

- Blocking strategy set by user: warn-only, block, or mixed mode (block for well-learned resources, warn for all others).
- Recommended to use detection only mode initially to test rules and apply exceptions.



Collect Sample

Generates tests for each model (length, char set, type) for each parameter

Exported as ModSecurity rules

Simple fixed size sample of requests used for elements and all models.

Matches ModSecurity rule capabilities.

Real World Issues

Handling of partial learning

- Rules generated for URLs for which sample was too low can be set to alert even if other rules block.
- Rules generated to alert/block on URLs and parameters not seen during learning.

Handling of application changes

- a change may result in a flood of events.

Negative security should still be used

- Filter attacks for learning.
- Provide protection during learning period and for partially learned and unlearned resources.
- Protection for free form text fields.

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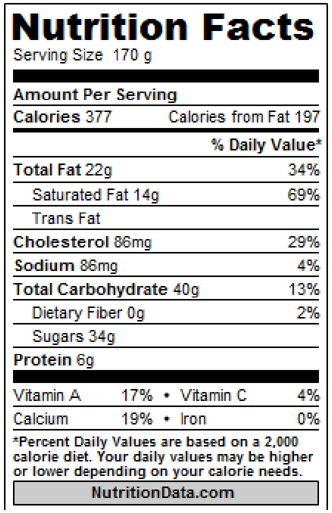
DESSERT

CONCLUSION



Nutrition Facts

Serving Size 170 g

Amount Per Serving	
Calories 377	Calories from Fat 197
	% Daily Value*
Total Fat 22g	34%
Saturated Fat 14g	69%
Trans Fat	
Cholesterol 86mg	29%
Sodium 86mg	4%
Total Carbohydrate 40g	13%
Dietary Fiber 0g	2%
Sugars 34g	
Protein 6g	
Vitamin A 17% • Vitamin C	4%
Calcium 19% • Iron	0%

*Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs.

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Positive Model Benefits

What can positive security achieve:

- Prevent information leakage
- Reduce attack surface
  - Request methods
  - Content encodings
- Debug parameters
- Prevent injection in some cases
- Reduce the likelihood of injection in others

Future Development (Short-Term)

Make ModProfiler useful within the current scope:

- Test with a wide range of sites
  - Involve community
  - Refine and handle edge cases
- Create models for popular open source products
  - Some have pledged support
- Continuous learning

Future Development (Long-Term)

Extend scope of ModProfiler:

- Output modelling
- User profiling
- Session profiling
- Extend data coverage
  - JSON
  - XML
- Real-time operation

Questions?

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Further information:
http://www.modsecurity.org/projects/modprofiler/