

**Question 1** *Boogle*

Boogle is a social networking website that's looking into expanding into other domains. Namely, they recently started a map service to try their hand at fusing that with social media. The URL for the main website is <https://www.boogle.com>, and they want to host the map service at <https://maps.boogle.com>.

Q1.1 For each of the following webpages, determine whether the webpage has the same origin as <http://boogle.com/index.html>, and provide a brief justification.

- i. <https://boogle.com/index.html>
- ii. <http://maps.boogle.com>
- iii. <http://boogle.com/home.html>
- iv. <http://maps.boogle.com:8080>

**Solution:**

- i. False. <https://boogle.com/index.html> and <http://boogle.com/index.html> do not have the same origin, since their protocols (https) and (http) are different.
- ii. False. <http://maps.boogle.com> and <http://boogle.com/index.html> do not have the same origin, since their domains (maps.boogle.com) and (boogle.com) are different. The same-origin policy performs string matching on the protocol, domain, and port.
- iii. True. The paths are not checked in the same-origin policy.
- iv. False. <http://maps.boogle.com:8080> and <http://boogle.com/index.html> do not have the same origin, because their ports (8080) and (80) are different. Note that if the port is not specified, the port defaults to 80 for http and 443 for https.

Q1.2 Describe how to make a cookie that will be sent to only Boogle's map website and its subdomains.

**Solution:** Set the domain parameter of the cookie to `.maps.boogle.com`

Q1.3 How can Boogle ensure that cookies are only transmitted encrypted so eavesdroppers on the network can't trivially learn the contents of the cookies?

**Solution:** Set the secure flag on each cookie.

Q1.4 Boogle wants to be able to host websites for users on their servers. They decide to host each user's website at [https://\[username\].boogle.com](https://[username].boogle.com). Why might this not be a good idea?

**Solution:** A malicious user could set cookies that would be sent to other users' sites as well as the entire .boogle.com domain. Also, any cookies meant for boogle.com will go to the malicious user.

Q1.5 Propose an alternate scheme so that Boogle can still host other users websites with less risk, and explain why this scheme is better.

Note: It is okay if the user sites interfere with each other, as long as they cannot affect official Boogle websites.

**Solution:** Boogle should create a new domain exclusively for user hosted content, like [https://\[username\].boogleusercontent.com](https://[username].boogleusercontent.com). This way, user sites cannot set cookies that will affect all boogle domains due to the cookie setting policy. This is known as a cookie tossing attack, and is one of the reasons why github hosts user sites on github.io instead of github.com (see <https://blog.github.com/2013-04-09-yummy-cookies-across-domains/>).

## Question 2 *Session Fixation*

A *session cookie* is used by most websites in order to manage user logins. When the user logs in, the server sends a randomly-generated session cookie to the user's browser. The server also stores the cookie value in a database along with the corresponding username. The user's browser sends the session cookie to the server whenever the user loads any page on the site. The server then looks the session cookie up in the database and retrieves the corresponding username. Using this, the server can know which user is logged in.

Some web application frameworks allow cookies to be set by the URL. For example, visiting the URL

`http://foobar.edu/page.html?sessionid=42.`

will result in the server setting the `sessionid` cookie to the value "42".

Q2.1 Can you spot an attack on this scheme?

Q2.2 Suppose the problem you spotted has been fixed as follows: `foobar.edu` now establishes new sessions with session IDs based on a hash of the tuple (username, time of connection). Is this secure? If not, what would be a better approach?

### **Solution:**

Q2.1 The main attack is known as *session fixation*. Say the attacker establishes a session with `foobar.edu`, receives a session ID of 42, and then tricks the victim into visiting `http://foobar.edu/browse.html?sessionid=42` (maybe through an `img` tag). The victim is now browsing `foobar.edu` with the attacker's account. Depending on the application, this could have serious implications. For example, the attacker could trick the victim to pay his bills instead of the victim's (as intended).

Another possibility is for the attacker to fix the session ID and then send the user a link to the log-in page. Depending on how the application is coded, it might so happen that the application allows the user to log-in but reuses the previous (attacker-set) session ID. For example, if the victim types in his username and password at `http://foobar.edu/login.html?sessionid=42`, then the session ID 42 would be bound to his identity. In such a scenario, the attacker could impersonate the victim on the site. This is uncommon nowadays, as most login pages reset the session ID to a new random value instead of reusing an old one.

Q2.2 The proposed fix is not secure since it solves the wrong problem - it doesn't fix either issue. In fact, it makes things weaker by significantly reducing the *entropy* of the session cookie.

The correct fix is for the server to generate cookie values afresh, rather than setting them based on the session ID provided via URL parameters. Also, the server shouldn't allow cookies to be set by the URL. This makes the attackers job more difficult as they have to do some form of XSS in order to manipulate the client's cookie vs. just clicking on a link.

### Question 3 *Cross-Site Request Forgery (CSRF)*

In a CSRF attack, a malicious user is able to take action on behalf of the victim. Consider the following example. Mallory posts the following in a comment on a chat forum:

```

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Of course, Patsy-Bank won't let just anyone request a transaction on behalf of any given account name. Users first need to authenticate with a password. However, once a user has authenticated, Patsy-Bank associates their session ID with an authenticated session state.

Q3.1 Explain what could happen when Alice visits the chat forum and views Mallory's comment.

**Solution:** The `img` tag embedded in the form causes the browser to make a request to `http://patsy-bank.com/transfer?amt=1000&to=mallory` with Patsy-Bank's cookie. If Alice was previously logged in (and didn't log out), Patsy-Bank might assume Alice is authorizing a transfer of 1000 USD to Mallory.

Q3.2 Patsy-Bank decides to check that the `Referer` header contains `patsy-bank.com`. Will the attack above work? Why or why not?

**Solution:** In most cases, it will solve the problem since the `Referer` header will contain the blog's URL instead of `patsy-bank.com`.

However, not all browsers send the `Referer` header, and even when they do, not all requests include it.

Q3.3 Describe one way Mallory can modify her attack to always get around this check.

**Solution:** She can have the link go to a URL under Mallory's control which contains `patsy-bank.com` such as `patsy-bank.attacker.com` or `attacker.com/attack?dummy=patsy-bank.com`. Then this page can redirect to the original malicious link. Now the `Referer` header will pass the check.

Another solution, is if the Patsy-Bank has a so-called "open redirect" `http://patsy-bank.com/redirect?to=url`, the referrer for the redirected request will be `http://patsy-bank.com/redirect?to=...`. An attacker can abuse this functionality by causing a victim's browser to fetch a URL like `http://patsy-bank.com/redirect?to=http://patsy-bank.com/transfer...`, and from `patsy-bank.com`'s perspective, it will see a subsequent request for `http://patsy-bank.com/transfer...` that indeed has a `Referer` from `patsy-bank.com`.

Q3.4 Recall that the `Referer` header provides the full URL. HTTP additionally offers an `Origin` header which acts the same as the `Referer` but only includes the website domain, not the entire URL. Why might the `Origin` header be preferred?

**Solution:** Leaking the entire URL can be a violation of privacy against users. As an example, consider Alice transferred money by visiting `http://patsy-bank.com/transfer?amt=1000&to=bob` and subsequently went to a website under an attacker's control - now the attacker has learned the exact amount of money Alice sent and to who. The `Origin` header would only leak that Alice was at the `patsy-bank.com`.

As a sidenote not directly related to the question, the `Origin` is a very useful way to solve the CSRF problem since it makes it much easier for multiple, trusted sites to make some action. For example, Patsy-Bank might trust `http://www.trustedcreditcardcompany.com` to directly transfer money from a user's account. This is a use-case that the CSRF token-based solution doesn't support cleanly.

Q3.5 Almost all browsers support an additional cookie field `SameSite`. When `SameSite=strict`, the browser will only send the cookie if the requested domain **and** origin domain correspond to the cookie's domain. Which CSRF attacks will this stop? Which ones won't it stop? Give one big drawback of setting `SameSite=strict`.

**Solution:** It stops almost all CSRF attacks, except those involving open redirects from the website in question or if the website itself has an XSS vulnerability.

However, setting `SameSite=strict` can greatly limit functionality since any external links that require a user to be logged in won't work. For instance, consider a friend sends you a Facebook link via email, clicking on that link will require you to sign in again since your session cookie wasn't sent with the request.