Security

SWE 432, Fall 2019

Web Application Development

Today

- Announcements
  - HW2 due next Monday
- Security
  - What is it?
  - Authentication
  - Most important types of attacks

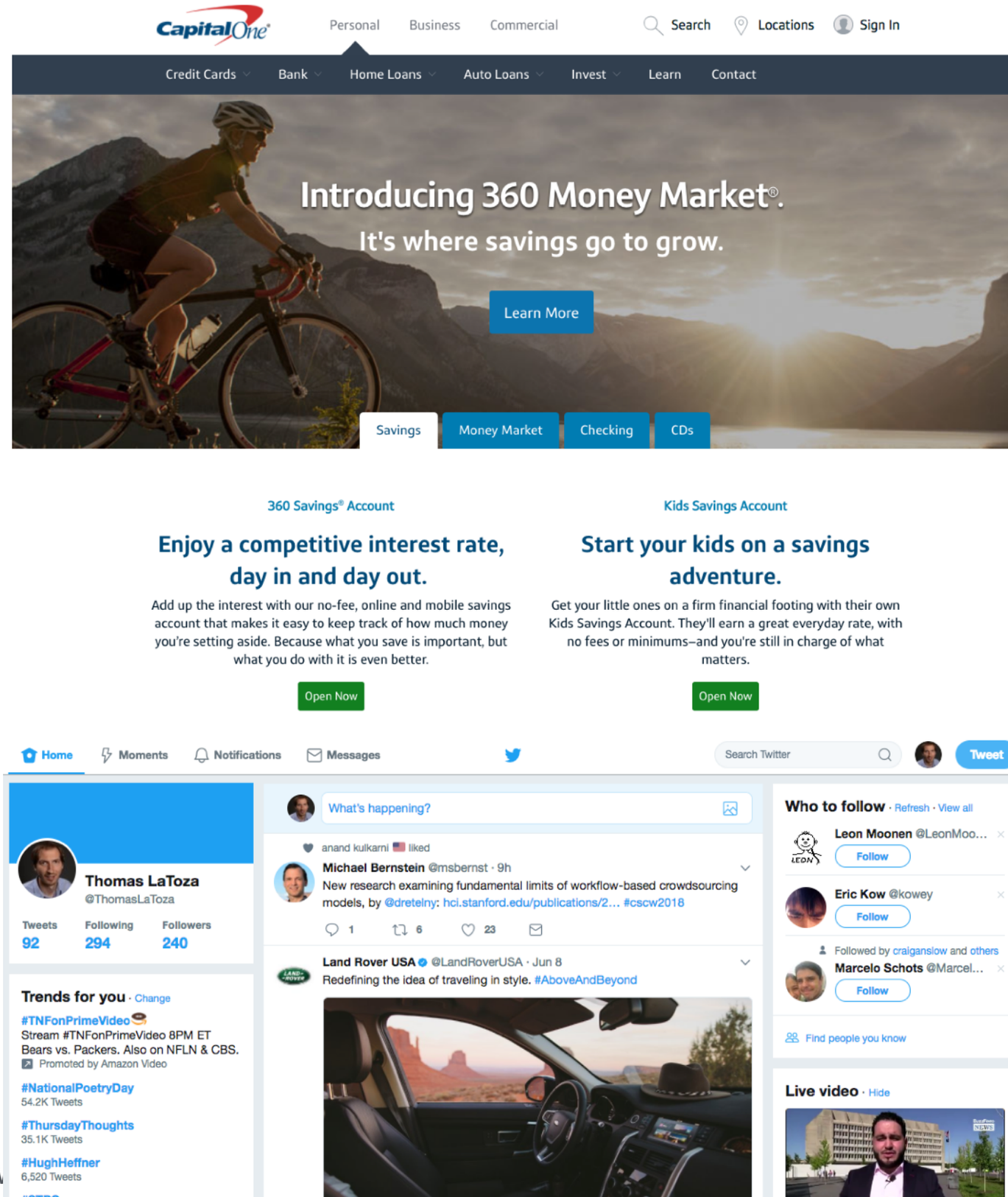
For further reading:

https://www.owasp.org/index.php/Category:OWASP_Top_Ten_Project#tab=OWASP_Top_10_for_2013

https://developer.mozilla.org/en-US/docs/Web/HTTP/Access_control_CORS

Security

- Why is it important?
  - Users' data is on the web
    - Blog comments, FB, Email, Banking, …
  - Can others steal it?
    - or who already has access?
  - Can others impersonate the user?
    - e.g., post on FB on the user's behalf



Security Requirements for Web Apps

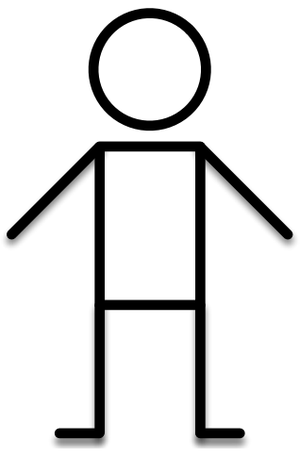
1. Authentication
   - Verify the **identify** of the parties involved
   - Who is it?
2. Authorization
   - Grant **access** to resources only to allowed users
   - Are you allowed?
3. Confidentiality
   - Ensure that **information** is given only to authenticated parties
   - Can you see it?
4. Integrity
   - Ensure that information is **not changed** or tampered with
   - Can you change it?

Threat Models

- What is being defended?
  - What resources are important to defend?
  - What malicious actors exist and what attacks might they employ?

- Who do we trust?
  - What entities or parts of system can be considered secure and trusted
  - Have to trust **something**!

Web Threat Models: Big Picture



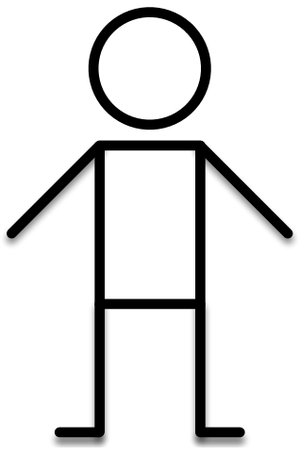
client page
(the “user”)

HTTP Request

HTTP Response

server

Web Threat Models: Big Picture



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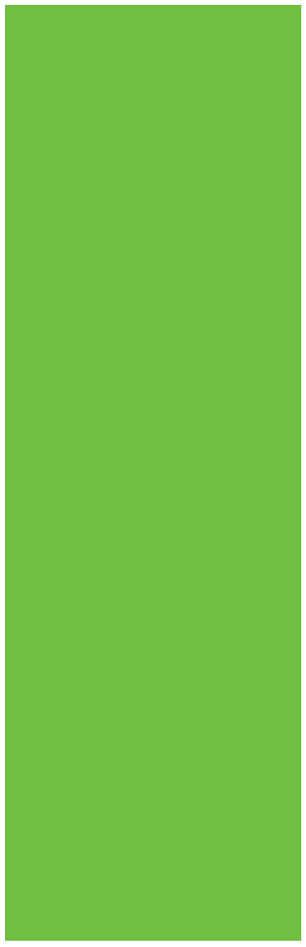
HTTP Request

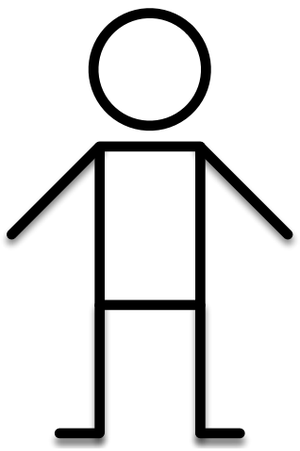
HTTP Response



server

Do I trust that this request *really* came from the user?

Web Threat Models: Big Picture



HTTP Request

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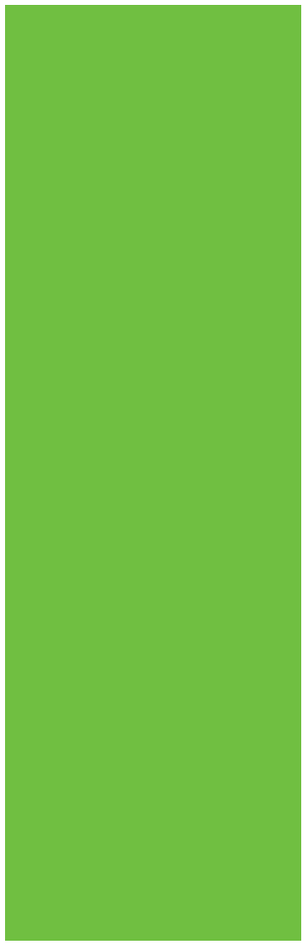

client page
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server

Do I trust that this response *really* came from the server?

Do I trust that this request *really* came from the user?

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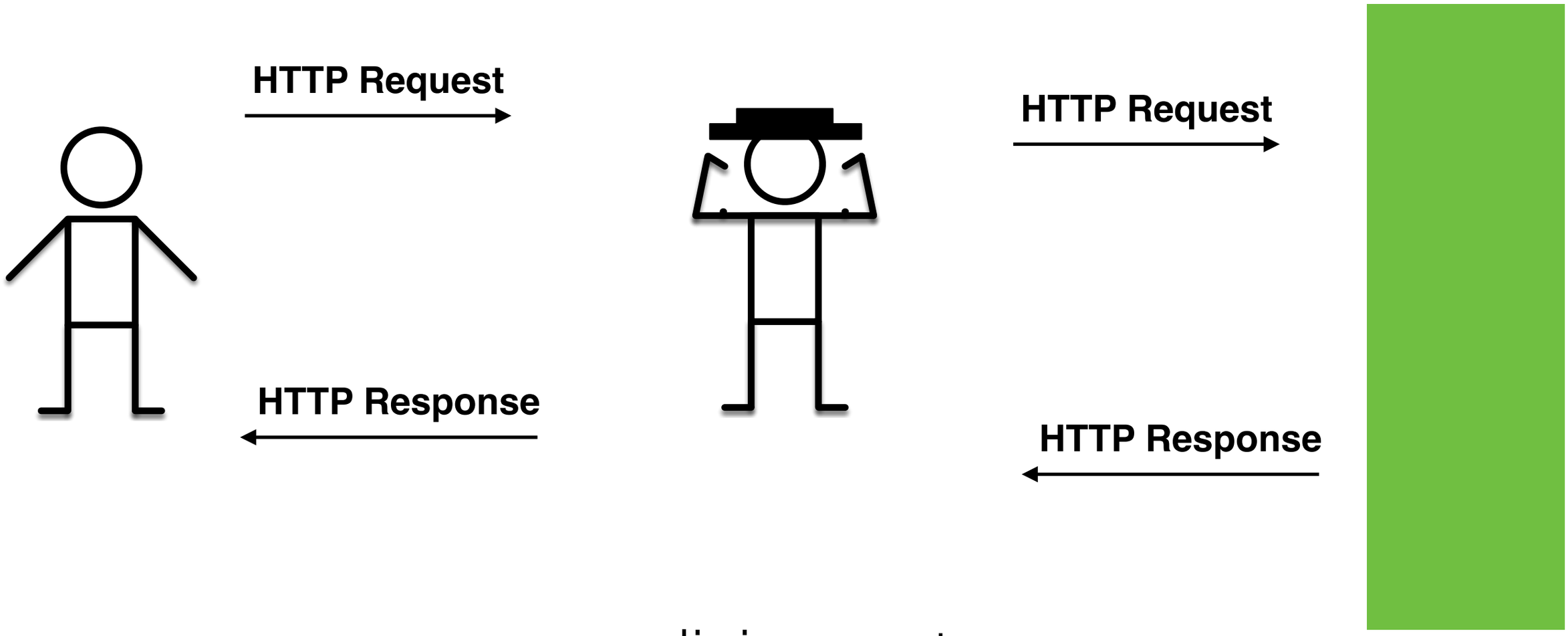


client page
(the "user")

malicious actor
"black hat"

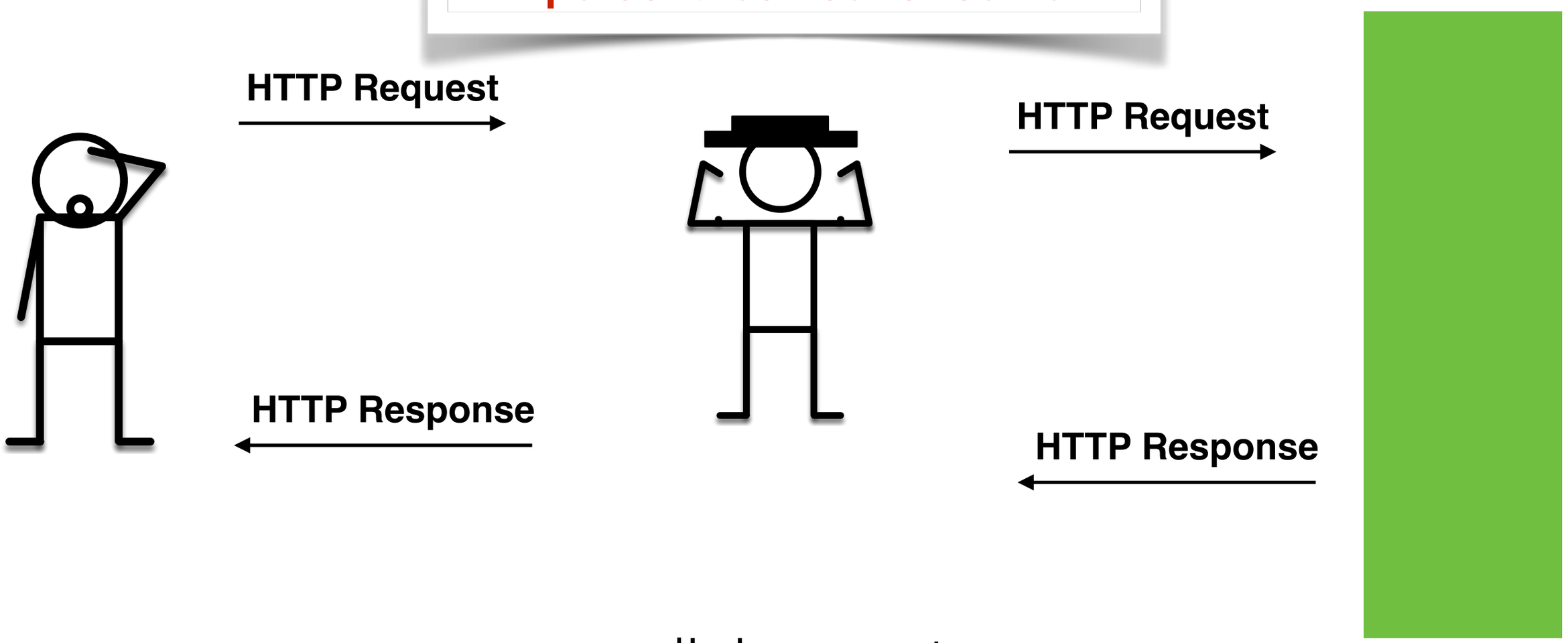
server

Do I trust that this response *really* came from the server?

Do I trust that this request *really* came from the user?

Web Threat Models: Big Picture

Might be "man in the middle" that intercepts requests and impersonates user or server.



client page (the "user")

malicious actor "black hat"

server

Do I trust that this response *really* came from the server?

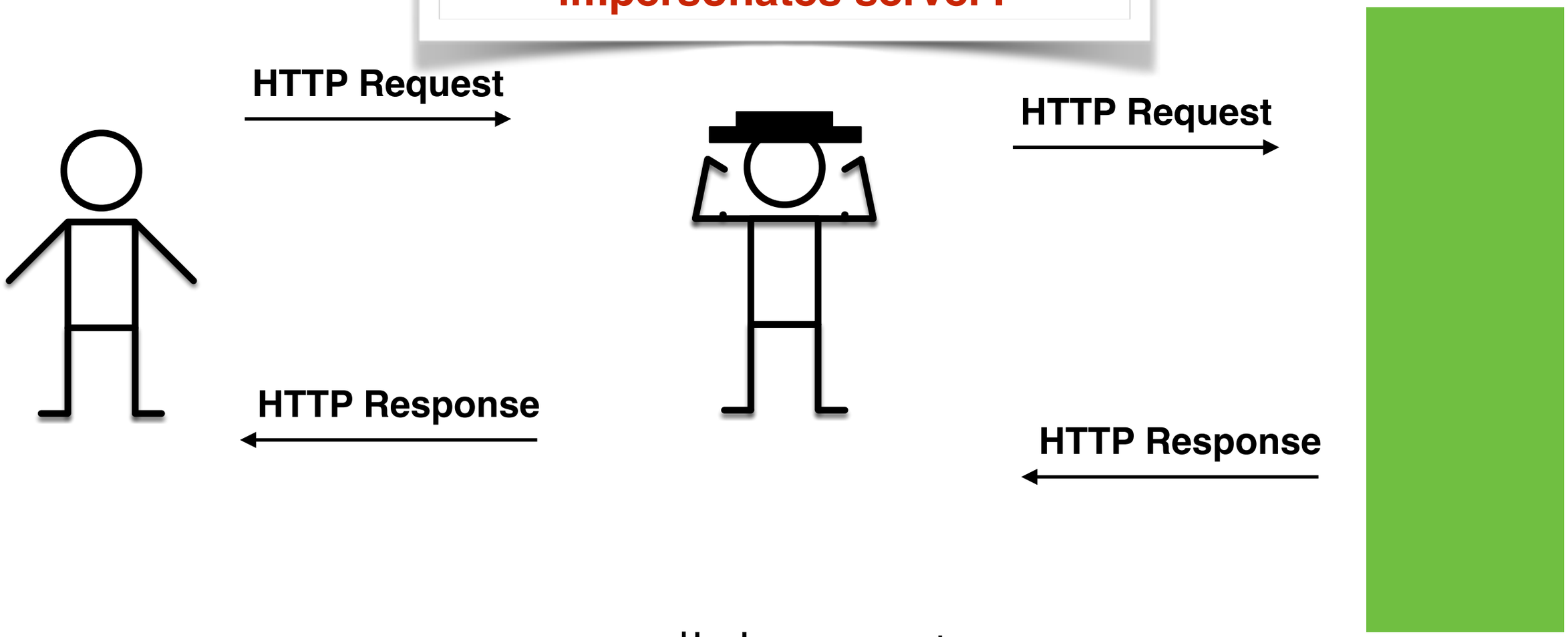
Do I trust that this request *really* came from the user?

Security Requirements for Web Apps

1. Authentication
   - Verify the **identify** of the parties involved
   - Threat: Impersonation. A person pretends to be someone they are not.
2. Authorization
3. Confidentiality
   - Ensure that **information** is given only to authenticated parties
   - Threat: Eavesdropping. Information leaks to someone that should not have it.
4. Integrity
   - Ensure that information is **not changed** or tampered with
   - Threat: **Tampering**.

Integrity and Confidentiality

What if malicious actor impersonates server?



client page
(the “user”)

malicious actor
“black hat”

server

Man in the middle

- Requests to server intercepted by man in the middle
  - Requests forwarded
  - But… response containing code edited, inserting malicious code
- Or could
  - Intercept and steal sensitive user data

HTTPS: HTTP over SSL

- Establishes secure connection from client to server
  - Uses SSL to encrypt traffic
- Ensures that others can't impersonate server by establishing certificate authorities that vouch for server.
- Server trusts an HTTPS connection iff
  - The user trusts that the browser software correctly implements HTTPS with correctly pre-installed certificate authorities.
  - The user trusts the certificate authority to vouch only for legitimate websites.
  - The website provides a valid certificate, which means it was signed by a trusted authority.
  - The certificate correctly identifies the website (e.g., certificate received for "https://example.com" is for "example.com" and not other entity).

Using HTTPS

- If using HTTPS, important that all scripts are loaded through HTTPS
  - If mixed script from untrusted source served through HTTP, attacker could still modify this script, defeating benefits of HTTPS
- Example attack:
  - Banking website loads Bootstrap through HTTP rather than HTTPS
  - Attacker intercepts request for Bootstrap script, replaces with malicious script that steals user data or executes malicious action

Authentication

- How can we know the identify of the parties involved
- Want to customize experience based on identity
  - But need to determine identity first!
- Options
  - Ask user to create a new username and password
    - Lots of work to manage (password resets, storing passwords securely, …)
    - Hard to get right (#2 on the OWASP Top 10 Vulnerability List)
    - User does not really want another password…
  - Use an authentication provider to authenticate user
    - Google, FB, Twitter, Github, …

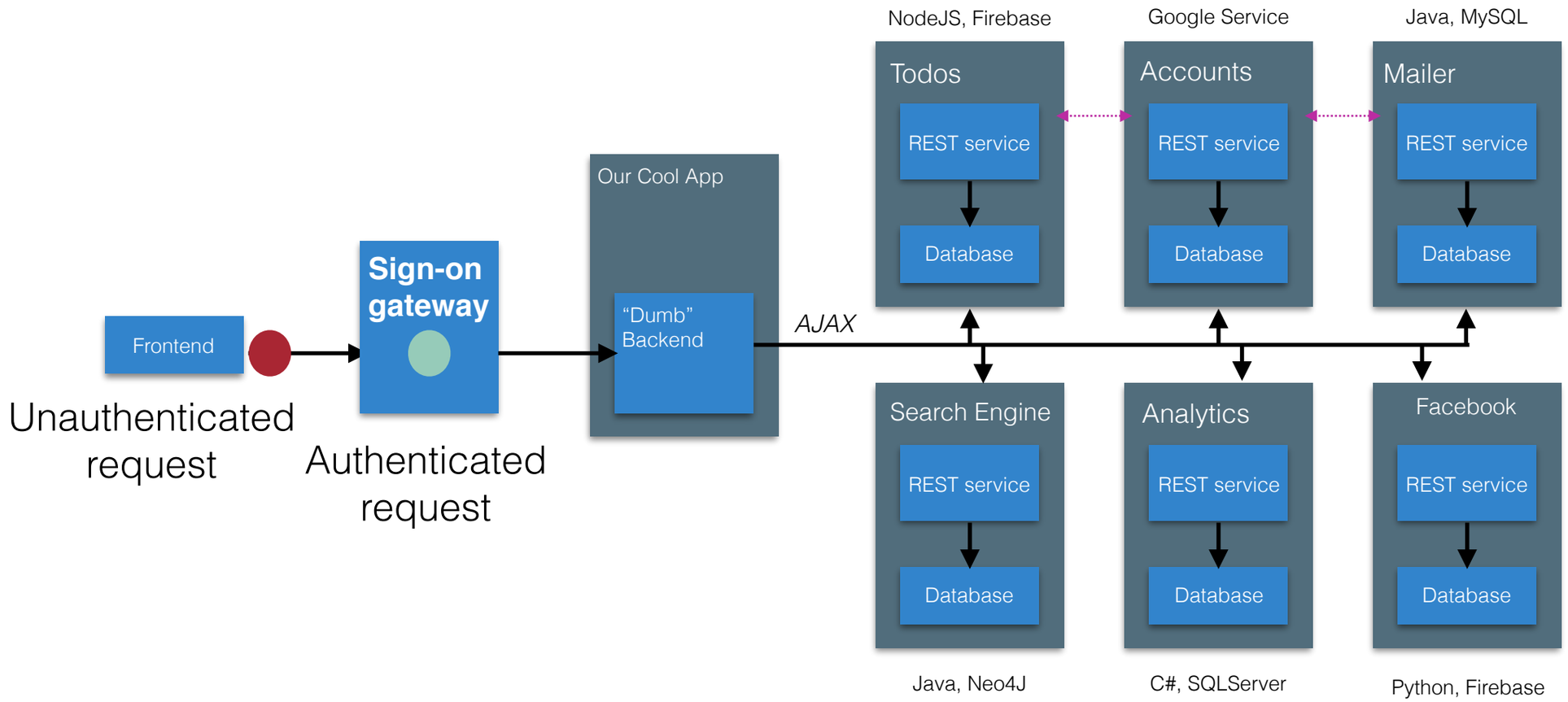
Authentication Provider

- Creates and tracks the identity of the user

- Instead of signing in directly to website, user signs in to authentication provider
  - Authentication provider issues token that uniquely proves identity of user

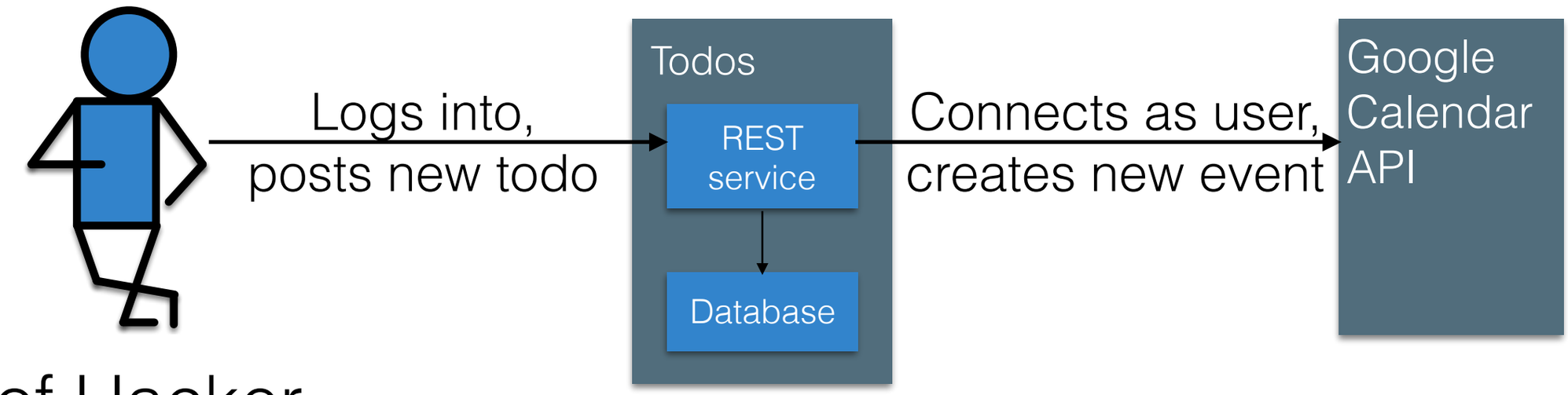
Sign-on Gateway

- Can place some magic “sign-on gateway” before out app - whether it’s got multiple services or just one



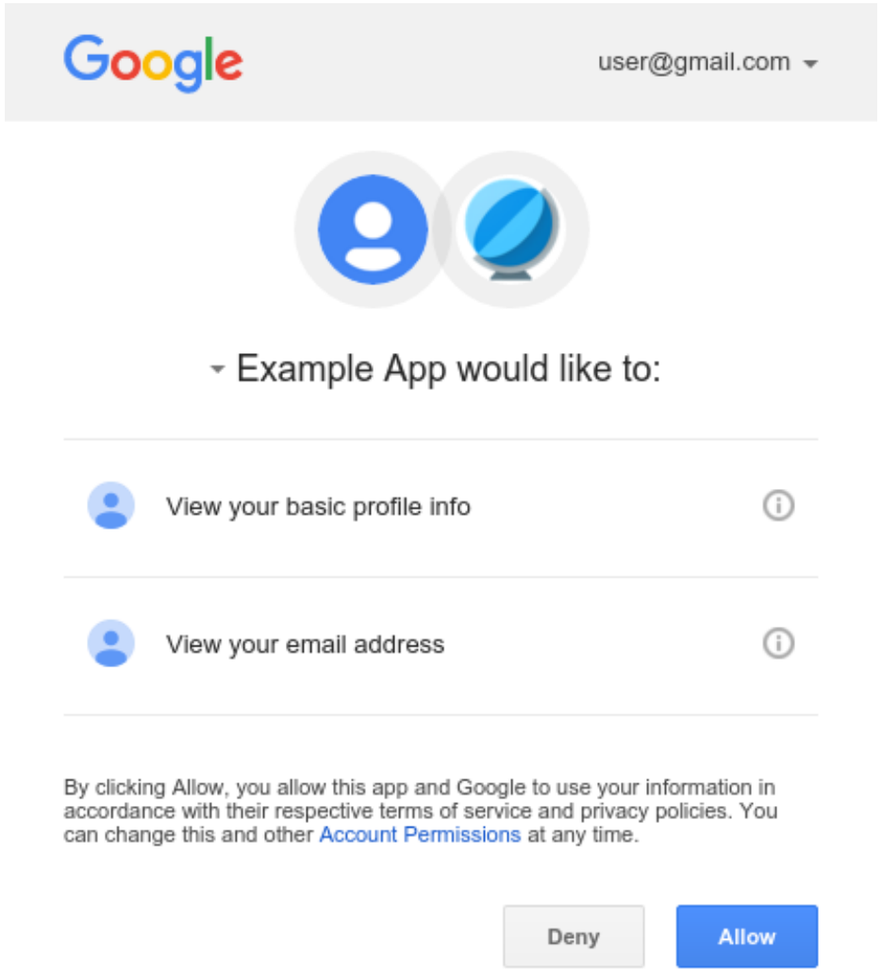
Bigger picture - authentication with multiple service providers

- Let's consider updating a Todos app so that it can automatically put calendar events on a Google Calendar



How does Todos tell Google that it's posting something for Prof Hacker? Should Prof Hacker tell the Todos app her Google password?

We’ve got something for that…

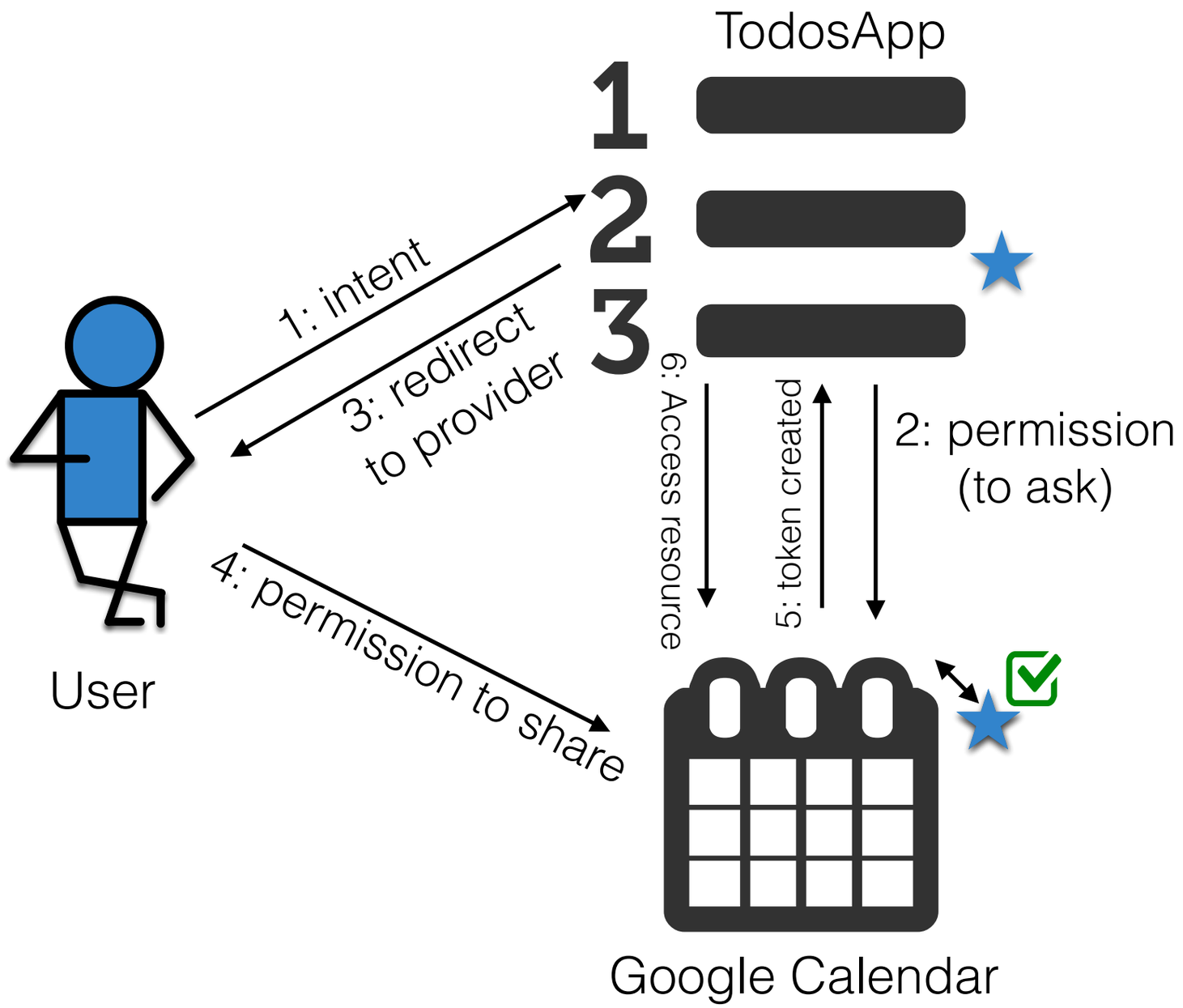


OAuth

- OAuth is a standard protocol for sharing information about users from a “service provider” to a “consumer app” **without** them disclosing their password to the consumer app
- 3 key actors:
  - User, consumer app, service provider app
    - E.x. “Prof Hacker,” “Todos App,” “Google Calendar”
- Service provider issues a **token** on the user’s behalf that the consumer can use
- Consumer holds onto this token on behalf of the user
- Protocol could be considered a conversation…

An OAuth Conversation

Goal: `TodosApp` can post events to `User's` calendar.
`TodosApp` never finds out `User's` email or password



Tokens?

A token is a **secret value**. Holding it gives us access to some privileged data. The token identifies our users and app.

Example token:

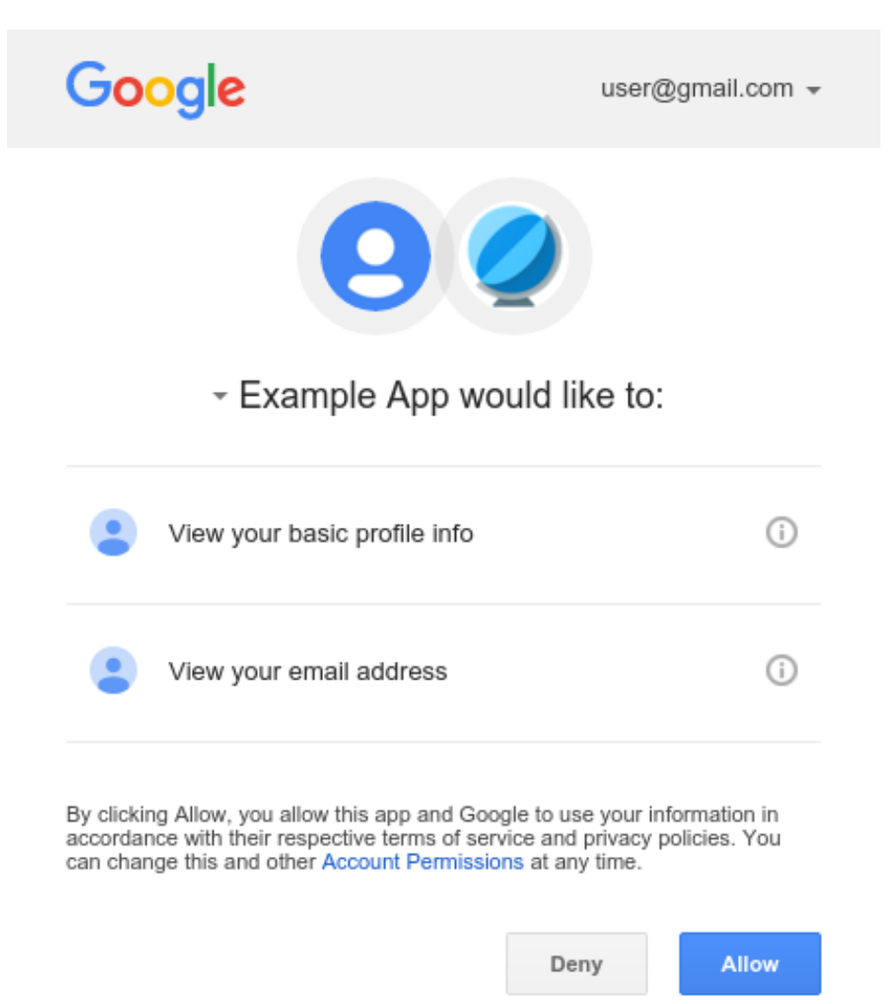

```
eyJhbGciOiJSUzI1NiIsImtpZCI6ImU3Yjg2NjFjMGUwM2Y3ZTk3NjQyNGUxZWFiMzI5OWIxNzRhNGVlNWUifQ.eyJpc3MiOiJodHRwczovL3NlY3VyZXRva
2VuLmdvb2dsZS5jb20vYXV0aGRlbW8tNzJhNDIiLCJuYW1lIjoiSm9uYXRoYW4gQmVsbCIsInBpY3R1cmUiOiJodHRwczovL2xoNS5nb29nbGV1c2VyY29ud
GVudC5jb20vLW0tT29jRlU1R0x3L0FBQUFBQUFBQUFJL0FBQUFBQUFBQUFBQUgwL0JVV2tONkRtTVJrL3Bob3RvLmpwZyIsImF1ZCI6ImF1dGhkZW1vLTcyYTQyI
iwiYXV0aF90aW1lIjoxNDc3NTI5MzcxLCJ1c2VyX2lkIjoiSk1RclFpdTlTUlRkeDY0YlR5Z0EzeHhEY3VIMiIsInN1YiI6IkpNUXJRaXU5U1JUZHg2NGJUe
WdBM3h4RGN1SDIiLCJpYXQiOjE0Nzc1MzA4ODUsImV4cCI6MTQ3NzUzNDQ4NSwiZW1haWwiOiJqb25iZWxsd2l0aG5vaEBnbWFpbC5jb20iLCJlbWFpbF92Z
XJpZmllZCI6dHJ1ZSwiZmlyZWJhc2UiOnsiaWRlbnRpdGllcyI6eyJnb29nbGUuY29tIjpbIjEwOTA0MDM1MjU3NDMxMjE1NDIxNiJdLCJlbWFpbCI6WyJqb
25iZWxsd2l0aG5vaEBnbWFpbC5jb20iXX0sInNpZ25faW5fcHJvdmlkZXIiOiJnb29nbGUuY29tIn19.rw1pPK377hDGmSaX31uKRphKt4i79aHjceepnA8A
2MppBQnPJlCqmgSapxs-Pwmp-1Jk382VooRwc8TfL6E1UQUl65yi2aYYzSx3mWMTWtPTHTkMN4E-GNprp7hX-
pqD3PncBh1bq1dThPNyjHLp3CUlPPO_QwaAeSuG5xALhzfYkvLSINty4FguD9vLHydpVHWscBNCDHACOqSeV5MzUs6ZYMnBIitFhbkak6z5OClvxGTGMhvI8
m11hIHdWgNGnDQNNoosiifzlwMqDHiF5t3KOL-mxtcNq33TvMAc43JElxnyB4g7qV2hJIOy4MLtLxphAfCeQZA3sxGf7vDXBQ
```


Decoded:


```
{
    "iss": "https://securetoken.google.com/authdemo-72a42",
    "name": “Alsyssa P Hacker”,
    "picture": "https://lh5.googleusercontent.com/-m-OocFU5GLw/AAAAAAAAAAI/AAAAAAAAAH0/BUWkN6DmMRk/photo.jpg",
    "aud": "authdemo-72a42",
    "auth_time": 1477529371,
    "user_id": "JMQrQiu9SRTdx64bTygA3xxDcuH2",
    "sub": "JMQrQiu9SRTdx64bTygA3xxDcuH2",
    "iat": 1477530885,
    "exp": 1477534485,
    "email": "alyssaphacker@gmail.com",
    "email_verified": true,
    "firebase": {
    "identities": {
        "google.com": ["109040352574312154216"],
            "email": ["alyssaphacker@gmail.com"]
    },
    "sign_in_provider": "google.com"
},
    "uid": "JMQrQiu9SRTdx64bTygA3xxDcuH2"
}
```

Trust in OAuth

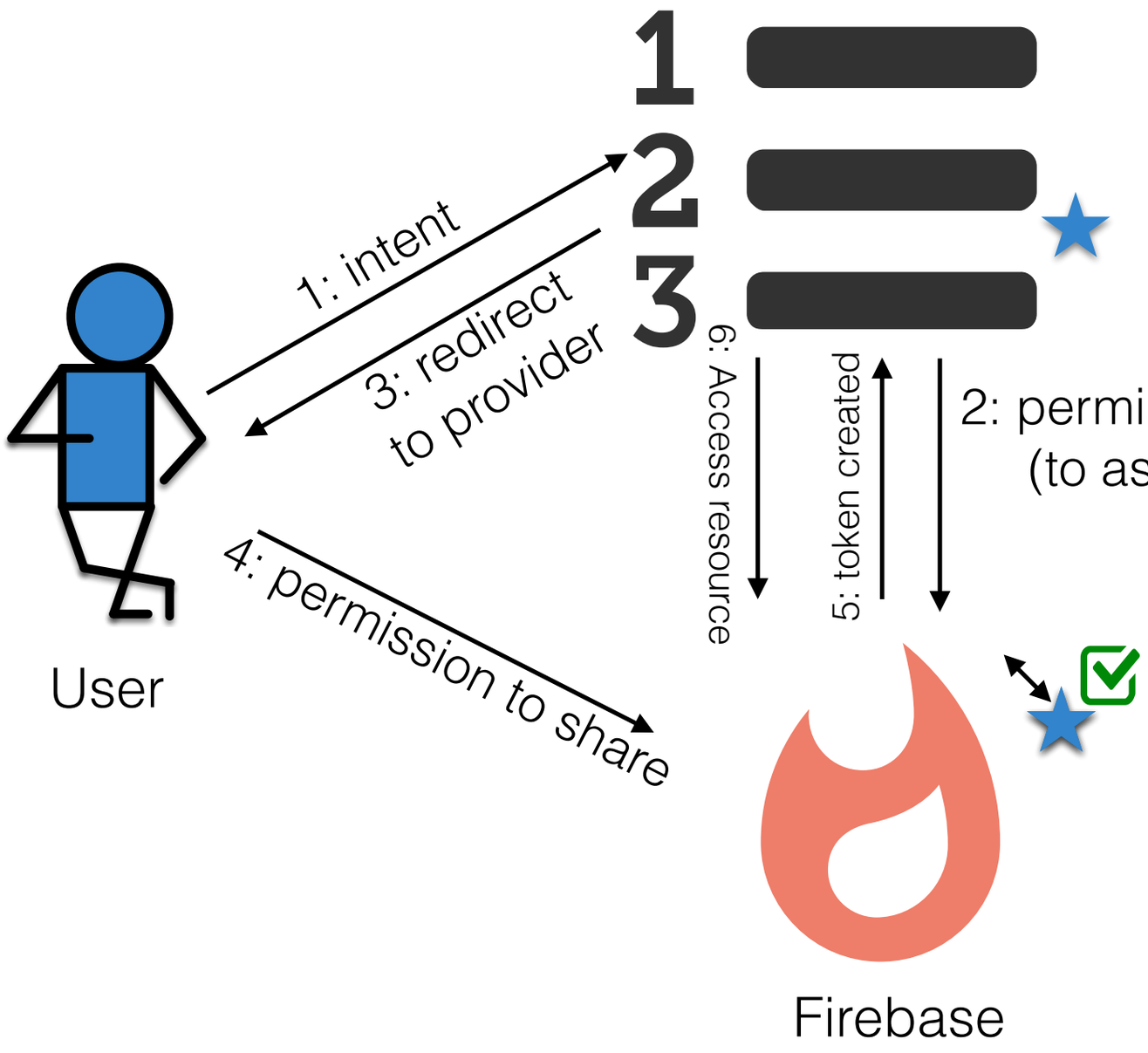
- How does the Service provider (Google calendar) know what the TodosApp is?
- Solution: When you set up OAuth for the first time, you must register your consumer app with the service provider
- Let the user decide
  - … they were the one who clicked the link after all



Authentication as a Service

- Whether we are building “microservices” or not, might make sense to farm out our authentication (user registration/logins) to another service
- Why?
  - Security
  - Reliability
  - Convenience
- We can use OAuth for this!

Using an Authentication Service



Firebase Authentication

- Firebase provides an entire suite of authentication services you can use to build into your app
- Can either use “federated” logins (e.g. login with google, facebook, GitHub credentials) or simple email/password logins. Use whichever you want.
- Getting started guide: https://github.com/firebase/FirebaseUI-Web
- Firebase handles browser local storage to track that the user is logged in across pages (woo)

Top 3 Web Vulnerabilities

- OWASP collected data on vulnerabilities
  - Surveyed 7 firms specializing in web app security
  - Collected 500,000 vulnerabilities across hundreds of apps and thousands of firms
  - Prioritized by prevalence as well as exploitability, detectability, impact

https://www.owasp.org/index.php/Category:OWASP_Top_Ten_Project

#3 - XSS: Cross Site Scripting

- User input that contains a *client-side* script that does not belong
  - A todo item:

/><script>alert("LASAGNA FOR PRESIDENT”);</script>

- Works when user input is used to render DOM elements without being escaped properly
- User input saved to server may be served to other users
  - Enables malicious user to execute code on other’s users browser
  - e.g., click ‘Buy’ button to buy a stock, send password data to third party, …

#2 - Broken Authentication and Session Management

- Building authentication is hard
  - Logout, password management, timeouts, secrete questions, account updates, …
- Vulnerability may exist if
  - User authentication credentials aren't protected when stored using hashing or encryption.
  - Credentials can be guessed or overwritten through weak account management functions (e.g., account creation, change password, recover password, weak session IDs).
  - Session IDs are exposed in the URL (e.g., URL rewriting).
  - Session IDs don't timeout, or user sessions or authentication tokens, particularly single sign-on (SSO) tokens, aren't properly invalidated during logout.
  - Session IDs aren't rotated after successful login.
  - Passwords, session IDs, and other credentials are sent over unencrypted connections.

#1 - Injection

- User input that contains *server-side* code that does not belong
- Usually comes up in context of SQL (which we aren't using)
  - e.g.,

```
String query = "SELECT * FROM accounts WHERE
custID='" + request.getParameter("id") + "'";
```

- Might come up in JS in context of eval
  - `eval(request.getParameter("code"));`
  - Obvious injection attack - don't do this!

Validating user input

- Escape Strings that originate from user
- Type of escaping depends on where data will be used
  - HTML - HTML entity encoding
  - URL - URL Escape
  - JSON - Javascript Escape
- Done automatically by some frameworks such as React
- More details: https://www.owasp.org/index.php/XSS_(Cross_Site_Scripting)_Prevention_Cheat_Sheet

Authentication: Sharing data between pages

- Browser loads many pages at the same time.
- Might want to share data between pages
  - Popup that wants to show details for data on main page
- Attack: malicious page
  - User visits a malicious page in a second tab
  - Malicious page steals data from page or its data, modifies data, or impersonates user

Solution: Same-Origin Policy

- Browser needs to differentiate pages that are part of same application from unrelated pages
- What makes a page similar to another page?
  - Origin: the **protocol**, **host**, and **port**

http://www.example.com/dir/page.html

- Different origins:

https://www.example.com/dir/page.html

http://www.example.com:80/dir/page.html

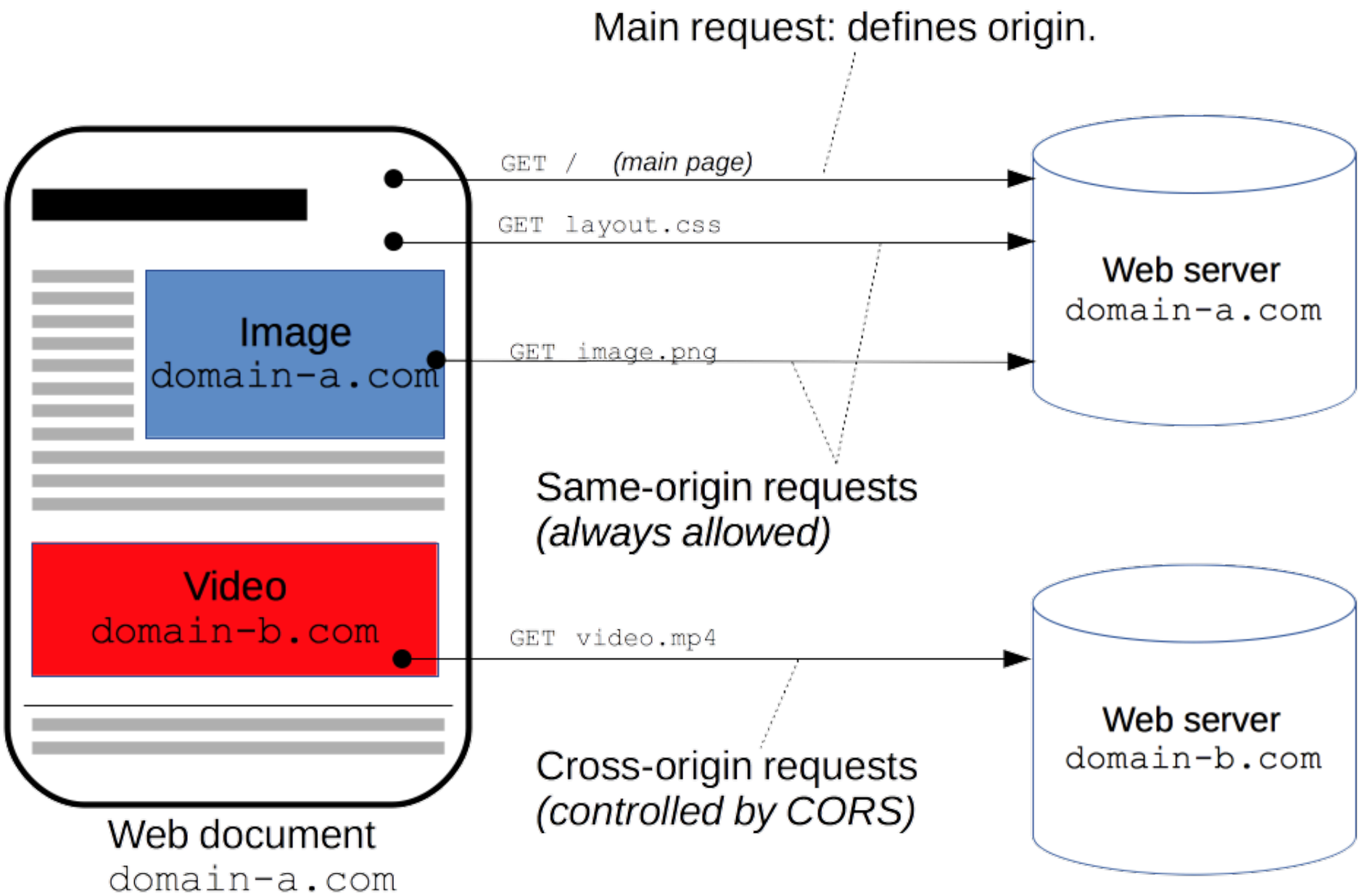
http://en.example.com:80/dir/page.html

https://en.wikipedia.org/wiki/Same-origin_policy

Same-Origin Policy

- "Origin" refers to the *page that is executing it*, NOT where the data comes from
  - Example:
    - In one HTML file, I directly include 3 JS scripts, each loaded from a different server
    - -> All have same "origin"
  - Example:
    - One of those scripts makes an AJAX call to yet another server
    - -> AJAX call not allowed
- Scripts contained in a page may access data in a second web page (e.g., its DOM) if they come from the same origin

Cross Origin Requests



https://developer.mozilla.org/en-US/docs/Web/HTTP/Access_control_CORS

CORS: Cross Origin Resource Sharing

- Same-Origin might be safer, but not really usable:
  - How do we make AJAX calls to other servers?
- Solution: Cross Origin Resource Sharing (CORS)
- HTTP header:

```
Access-Control-Allow-Origin: <server or wildcard>
```

- In Express:

```
res.header("Access-Control-Allow-Origin", "*");
```

Takeaways

- Think about all potential threat models
  - Which do you care about
  - Which do you not care about

- What user data are you retaining
  - Who are you sharing it with, and what might they do with it