Security

SWE 432, Fall 2017

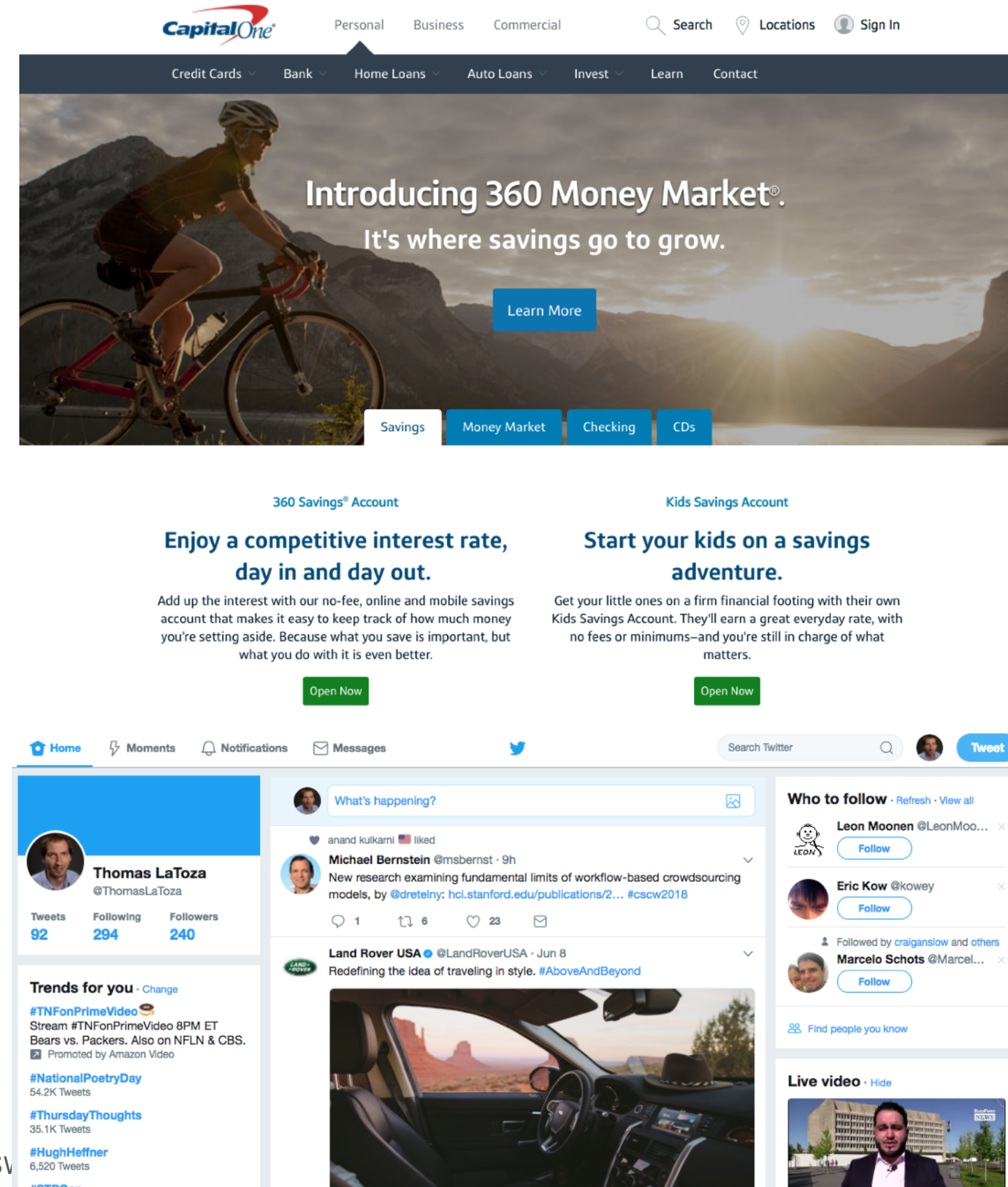
Design and Implementation of Software for the Web

Today

- Security
  - What is it?
  - Most important types of attacks
- Authorization
  - oAuth

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

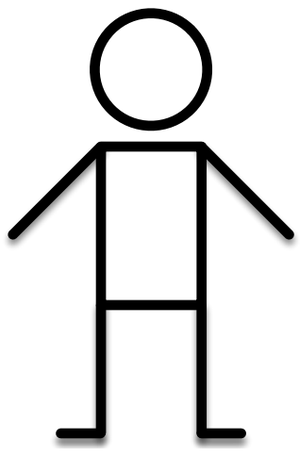
1. Authentication
   - Verify the **identify** of the parties involved
   - Who is it?
2. Authorization
   - Grant **access** to resources only to allowed users
   - Are you allowed?
3. Confidentiality
   - Ensure that **information** is given only to authenticated parties
   - Can you see it?
4. Integrity
   - 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



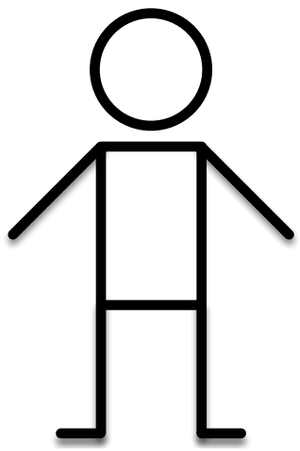
client page
(the “user”)

HTTP Request

HTTP Response

server

Web Threat Models: Big Picture



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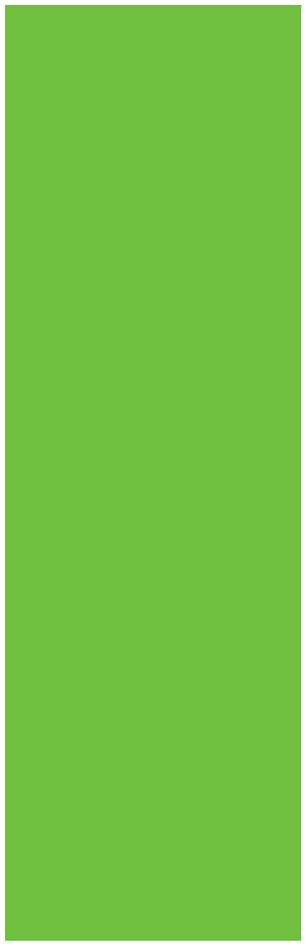
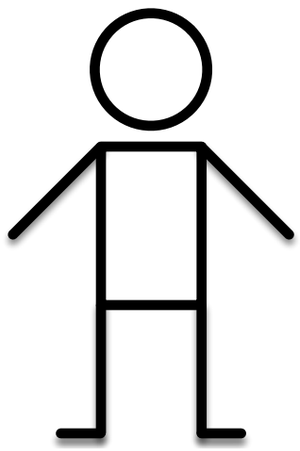


server

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

Web Threat Models: Big Picture



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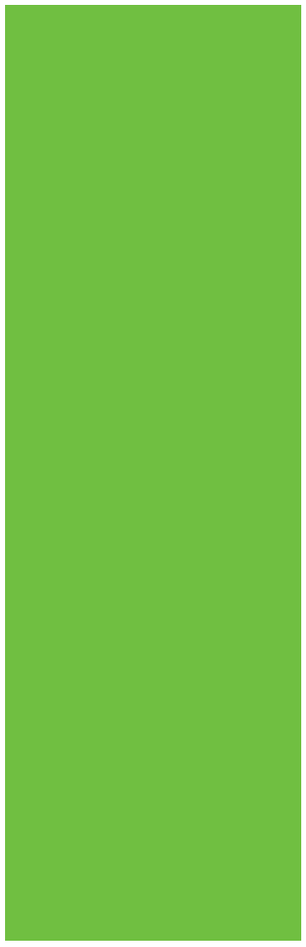

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Do I trust that this response *really* came from the server?

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

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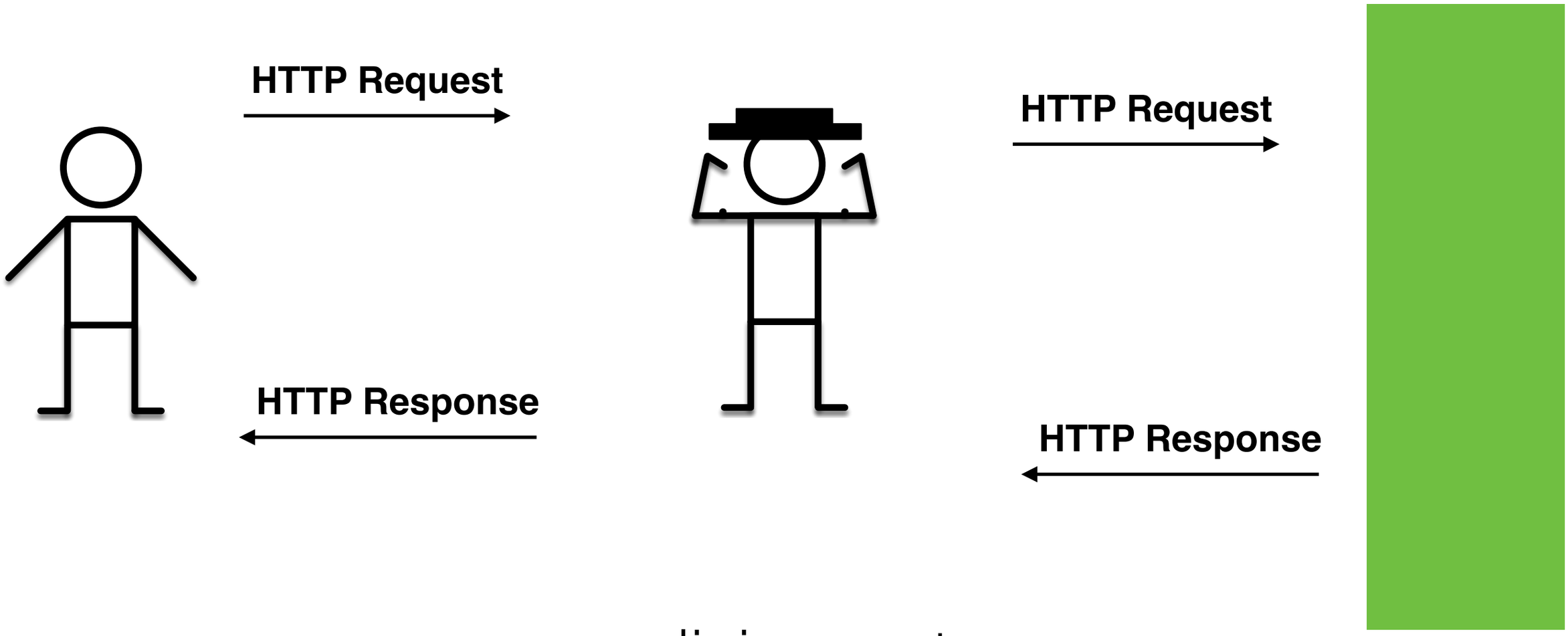


client page
(the "user")

malicious actor
"black hat"

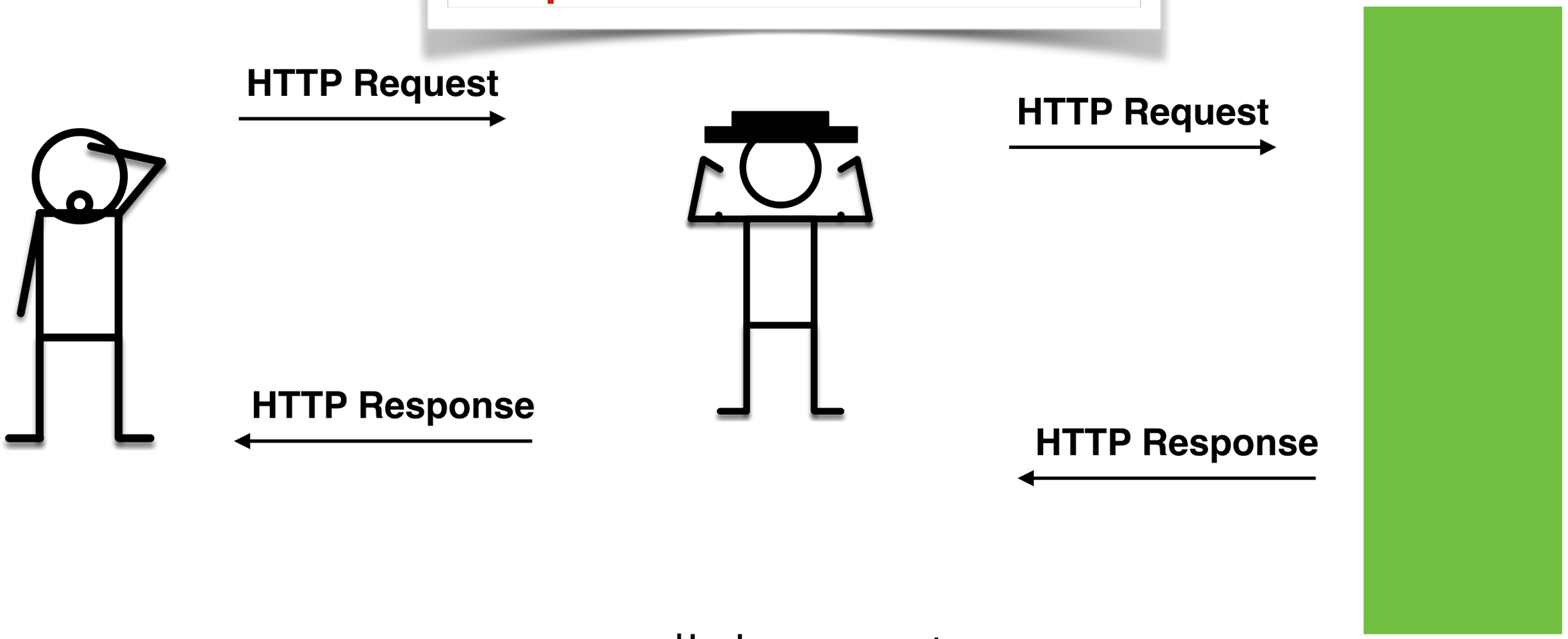
server

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"

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

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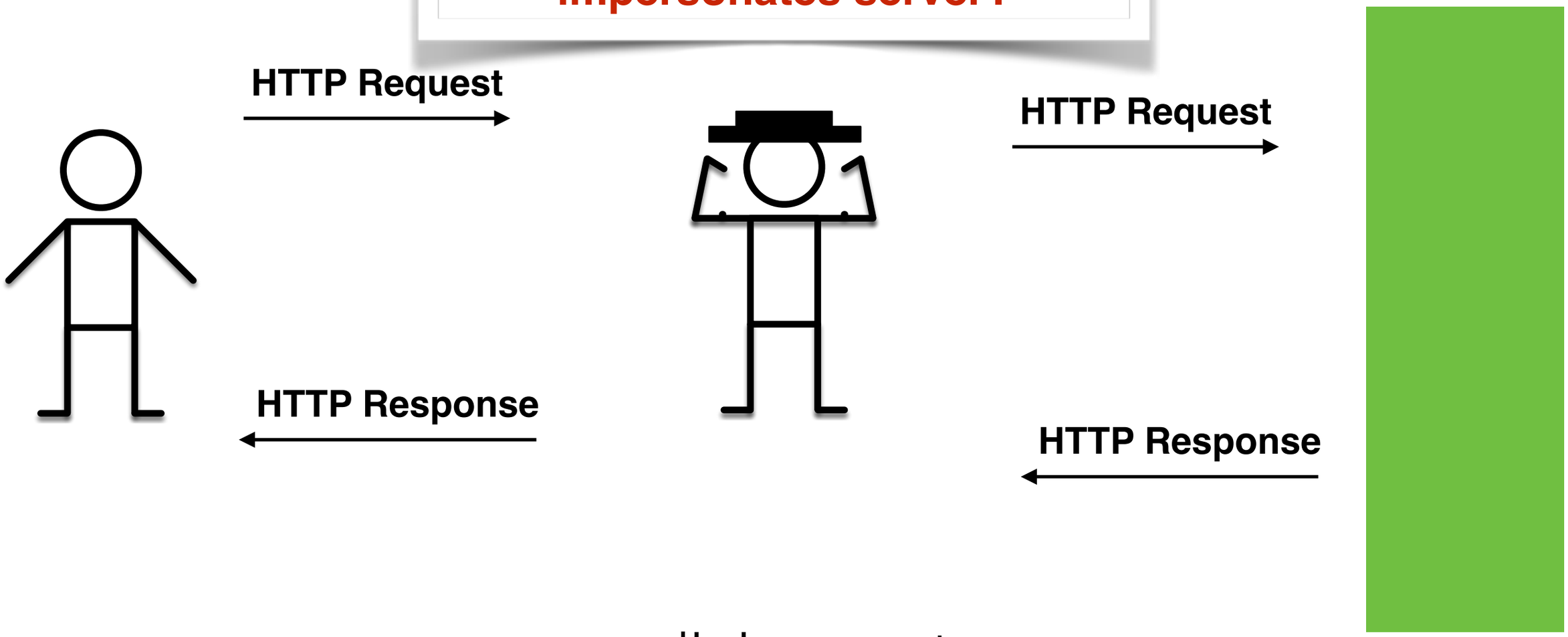
Security Requirements for Web Apps

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
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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 jQuery through HTTP from a CDN rather than HTTPS
  - Attacker intercepts request for jQuery 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, …

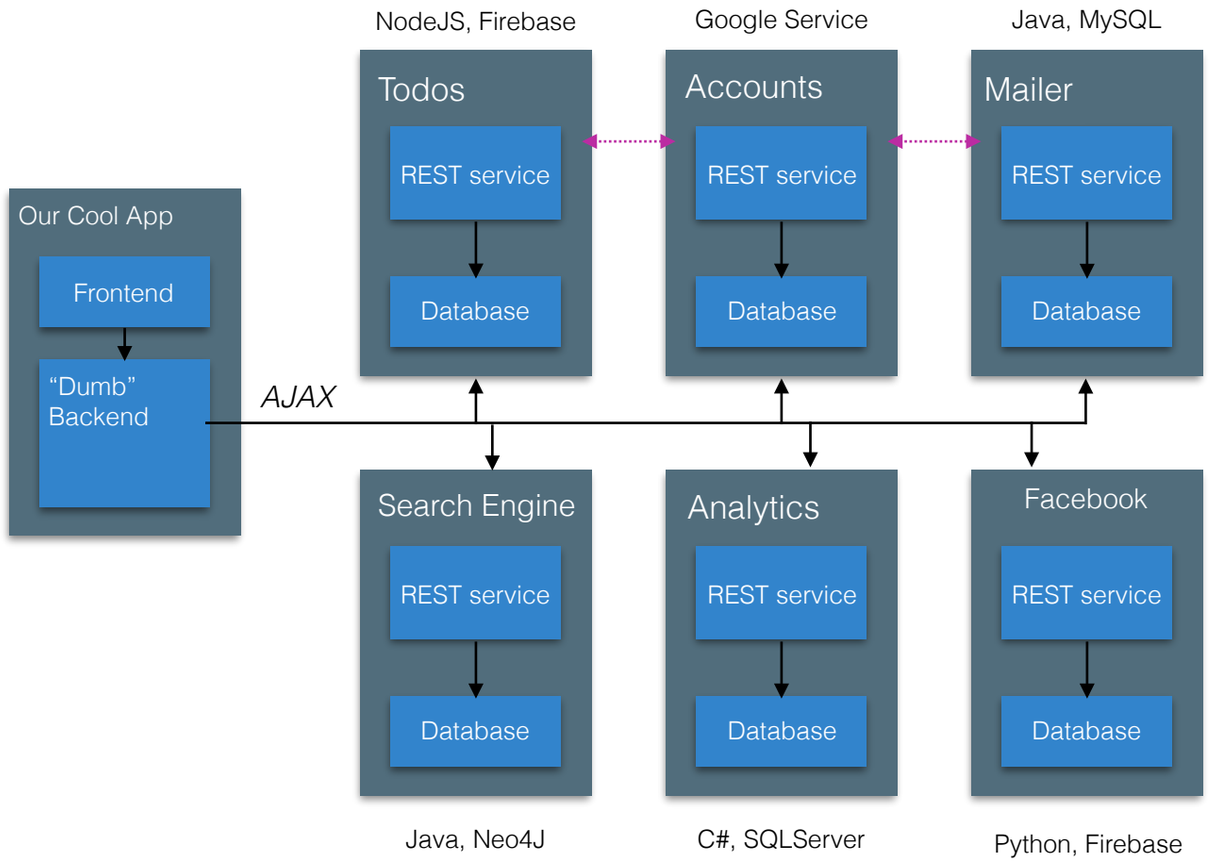
Authentication Provider

- 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
  - Talk more next lecture about how these tokens work

Microservices & Authentication

- If using microservices, how do we decide who is logged in?
- Typical solution: Sign-on gateway



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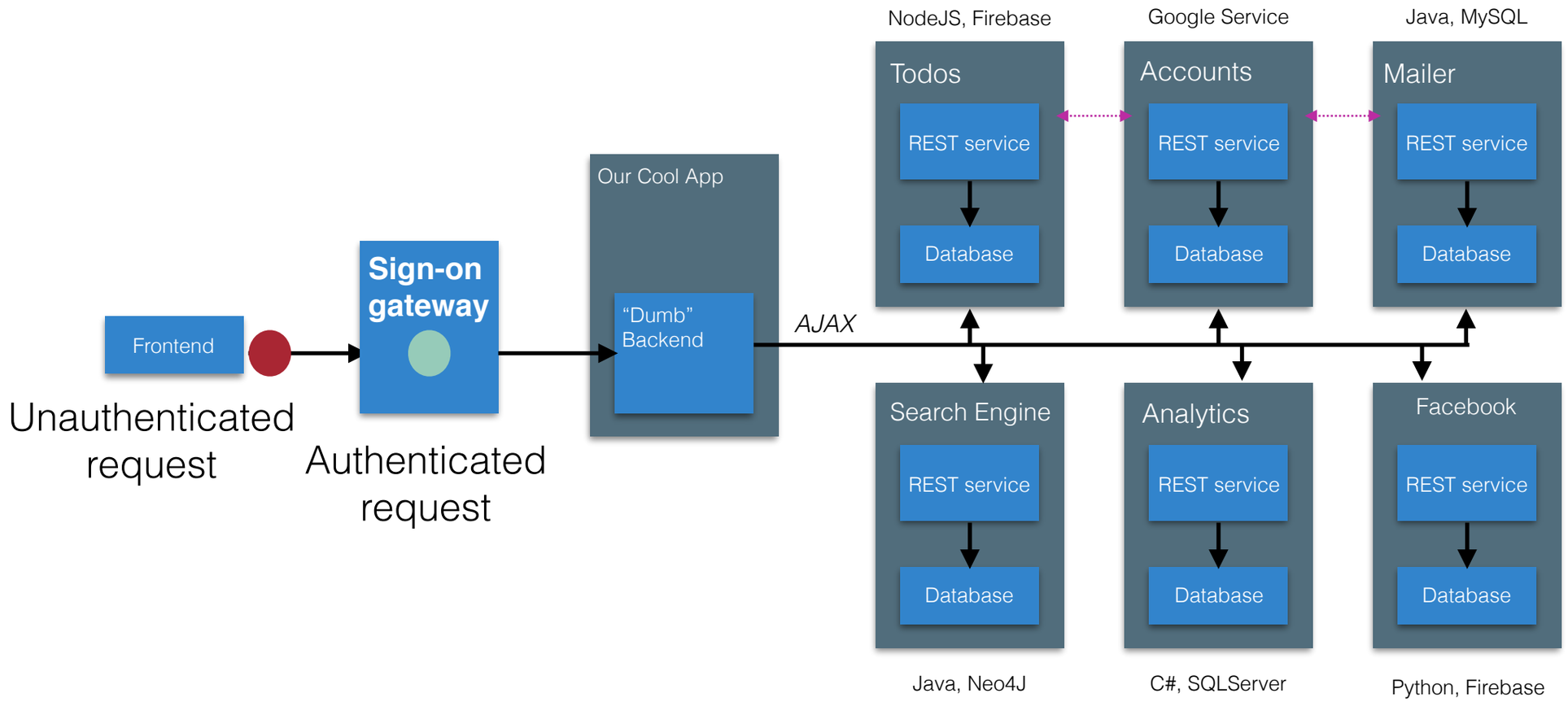
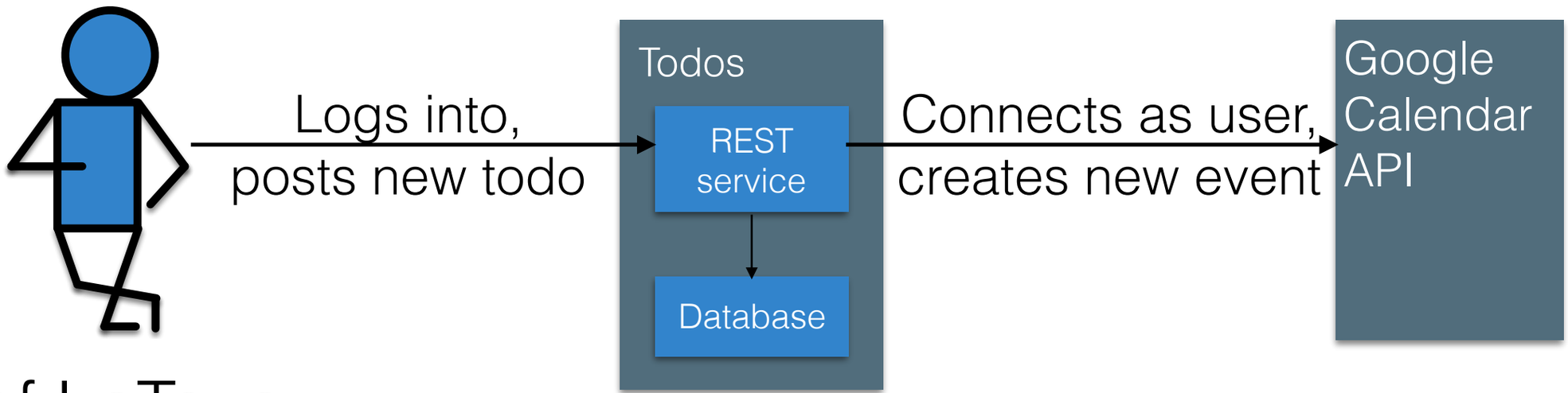


Authentication & Authorization

- Putting this sign on gateway will ensure that people are signed in
- But how do we ensure that someone is **authorized** to view some given data or make some request?
- Role of individual services to check back (either with authorization service, or some other service)

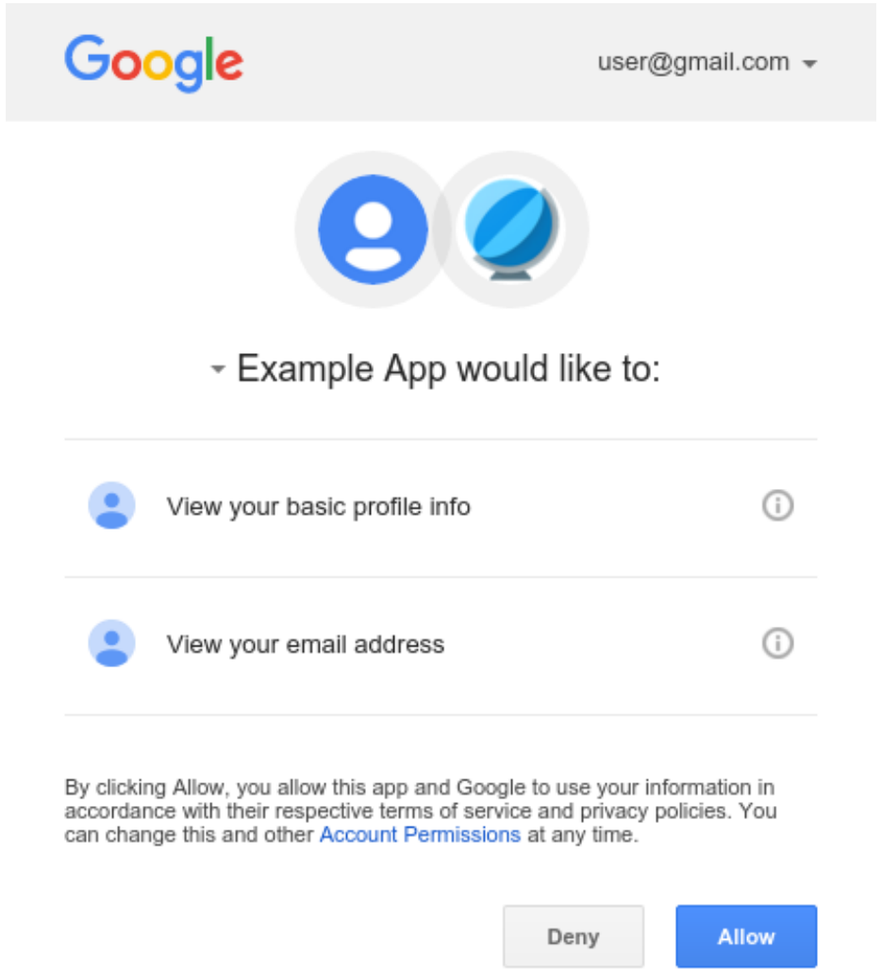
Bigger picture - authentication with multiple service providers

- 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 LaToza? Should Prof LaToza tell the Todos app his Google password?

We’ve got something for that…

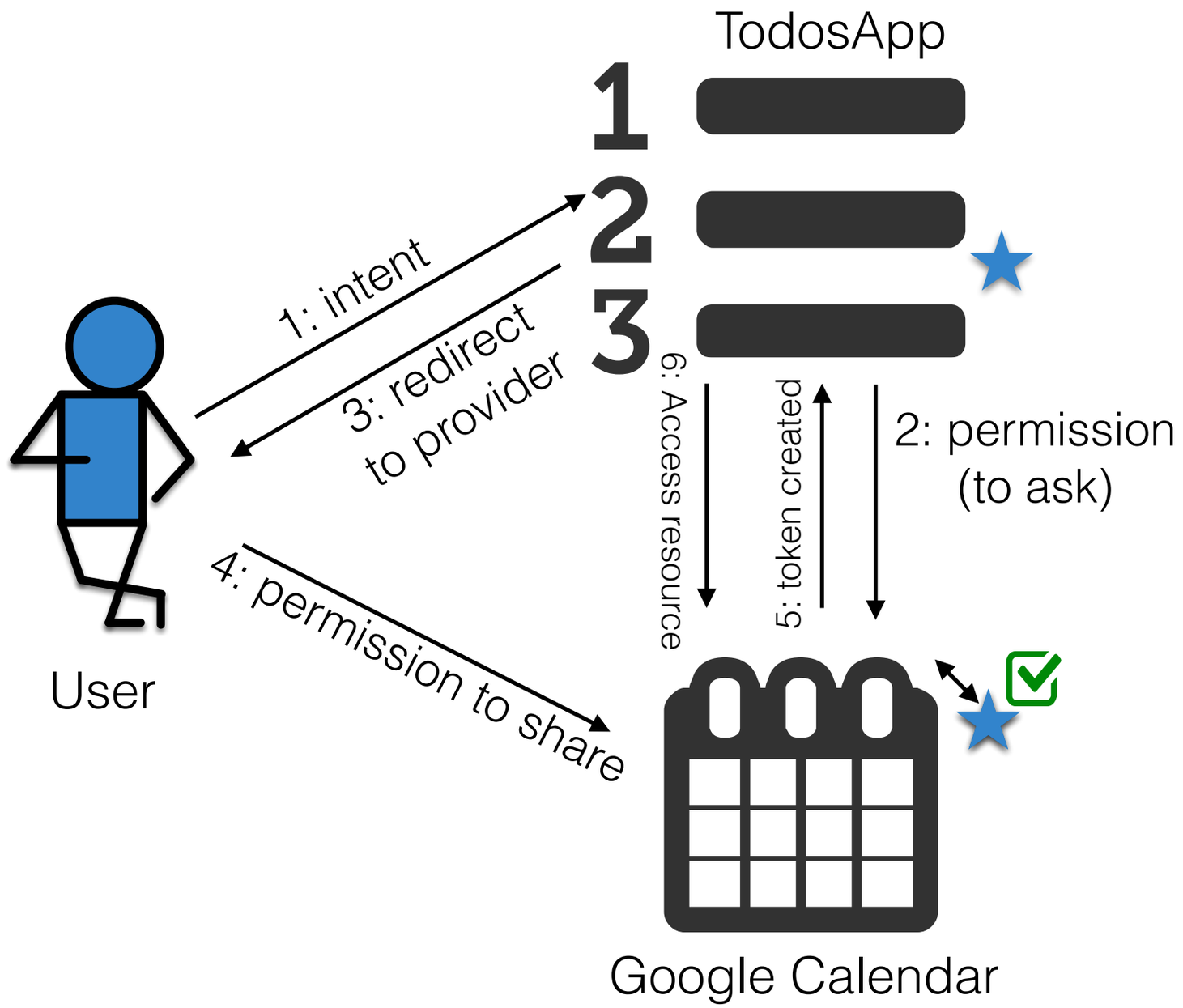


OAuth

- 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 LaToza,” “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:

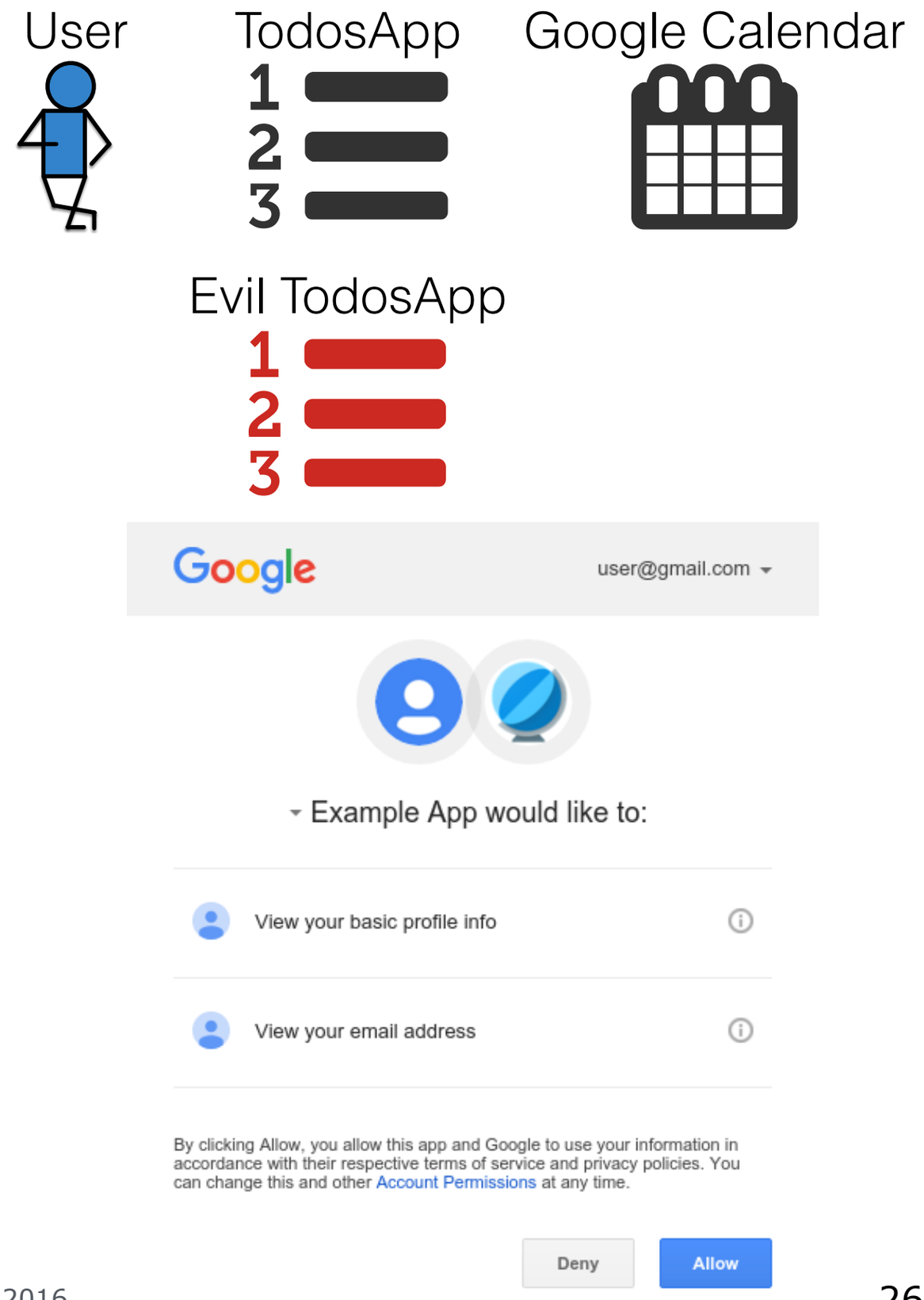

```
eyJhbGciOiJSUzI1NiIsImtpZCI6ImU3Yjg2NjFjMGUwM2Y3ZTk3NjQyNGUxZWFiMzI5OWIxNzRhNGVlNWUifQ.eyJpc3MiOiJodHRwczovL3NlY3VyZXRva
2VuLmdvb2dsZS5jb20vYXV0aGRlbW8tNzJhNDIiLCJuYW1lIjoiSm9uYXRoYW4gQmVsbCIsInBpY3R1cmUiOiJodHRwczovL2xoNS5nb29nbGV1c2VyY29ud
GVudC5jb20vLW0tT29jRlU1R0x3L0FBQUFBQUFBQUFJL0FBQUFBQUFBQUgwL0JVV2tONkRtTVJrL3Bob3RvLmpwZyIsImF1ZCI6ImF1dGhkZW1vLTcyYTQyI
iwiYXV0aF90aW1lIjoxNDc3NTI5MzcxLCJ1c2VyX2lkIjoiSk1RclFpdTlTUlRkeDY0YlR5Z0EzeHhEY3VIMiIsInN1YiI6IkpNUXJRaXU5U1JUZHg2NGJUe
WdBM3h4RGN1SDIiLCJpYXQiOjE0Nzc1MzA4ODUsImV4cCI6MTQ3NzUzNDQ4NSwiZW1haWwiOiJqb25iZWxsd2l0aG5vaEBnbWFpbC5jb20iLCJlbWFpbF92Z
XJpZmllZCI6dHJ1ZSwiZmlyZWJhc2UiOnsiaWRlbnRpdGllcyI6eyJnb29nbGUuY29tIjpbIjEwOTA0MDM1MjU3NDMxMjE1NDIxNiJdLCJlbWFpbCI6WyJqb
25iZWxsd2l0aG5vaEBnbWFpbC5jb20iXX0sInNpZ25faW5fcHJvdmlkZXIiOiJnb29nbGUuY29tIn19.rw1pPK377hDGmSaX31uKRphKt4i79aHjceepnA8A
2MppBQnPJlCqmgSapxs-Pwmp-1Jk382VooRwc8TfL6E1UQUl65yi2aYYzSx3mWMTWtPTHTkMN4E-GNprp7hX-
pqD3PncBh1bq1dThPNyjHLp3CUlPPO_QwaAeSuG5xALhzfYkvLSINty4FguD9vLHydpVHWscBNCDHACOqSeV5MzUs6ZYMnBIitFhbkak6z5OClvxGTGMhvI8
m11hIHdWgNGnDQNNoosiifzlwMqDHiF5t3KOL-mxtcNq33TvMAc43JElxnyB4g7qV2hJIOy4MLtLxphAfCeQZA3sxGf7vDXBQ
```


Decoded:


```
{
    "iss": "https://securetoken.google.com/authdemo-72a42",
    "name": “Thomas LaToza",
    "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": "latoza@gmail.com",
    "email_verified": true,
    "firebase": {
    "identities": {
        "google.com": ["109040352574312154216"],
            "email": ["latoza@gmail.com"]
    },
    "sign_in_provider": "google.com"
},
    "uid": "JMQrQiu9SRTdx64bTygA3xxDcuH2"
}
```

Trust in OAuth

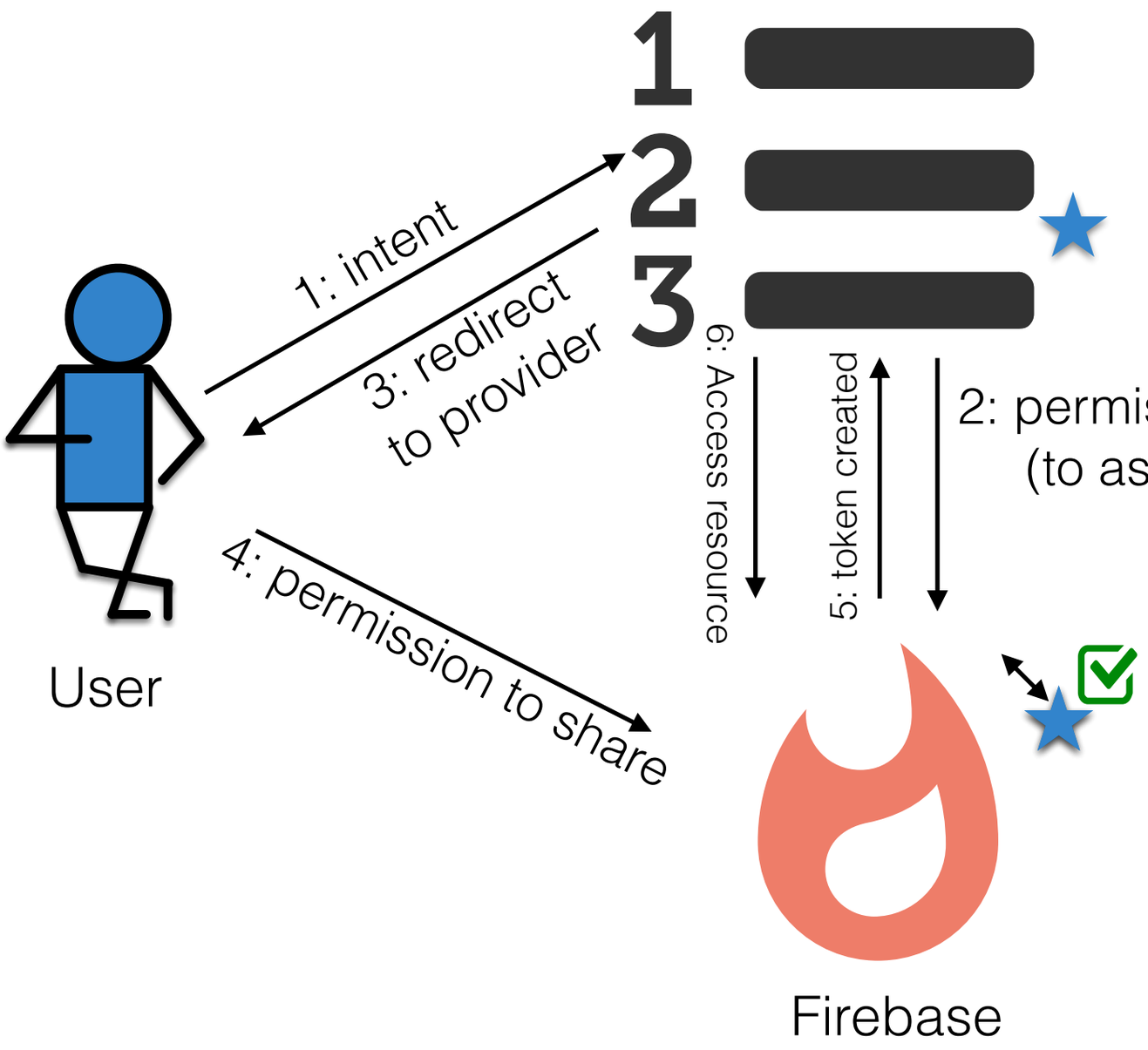
- How does the Service provider (Google calendar) know what the TodosApp is?
- Solution: When you set up OAuth for the first time, you must register your consumer app with the service provider
- Let the user decide
  - … they were the one who clicked the link after all



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!
- We’re going to use Firebase’s authentication API in our homework this week

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
- For backend: https://firebase.google.com/docs/auth/server/verify-id-tokens
- Firebase handles browser local storage to track that the user is logged in across pages (woo)

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
  - Cookies that let user login once for a page and still be logged in when visiting page in separate tab
- Attack: malicious page
  - User visits a malicious page in a second tab
  - Malicious page steals data from page or its cookies, 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

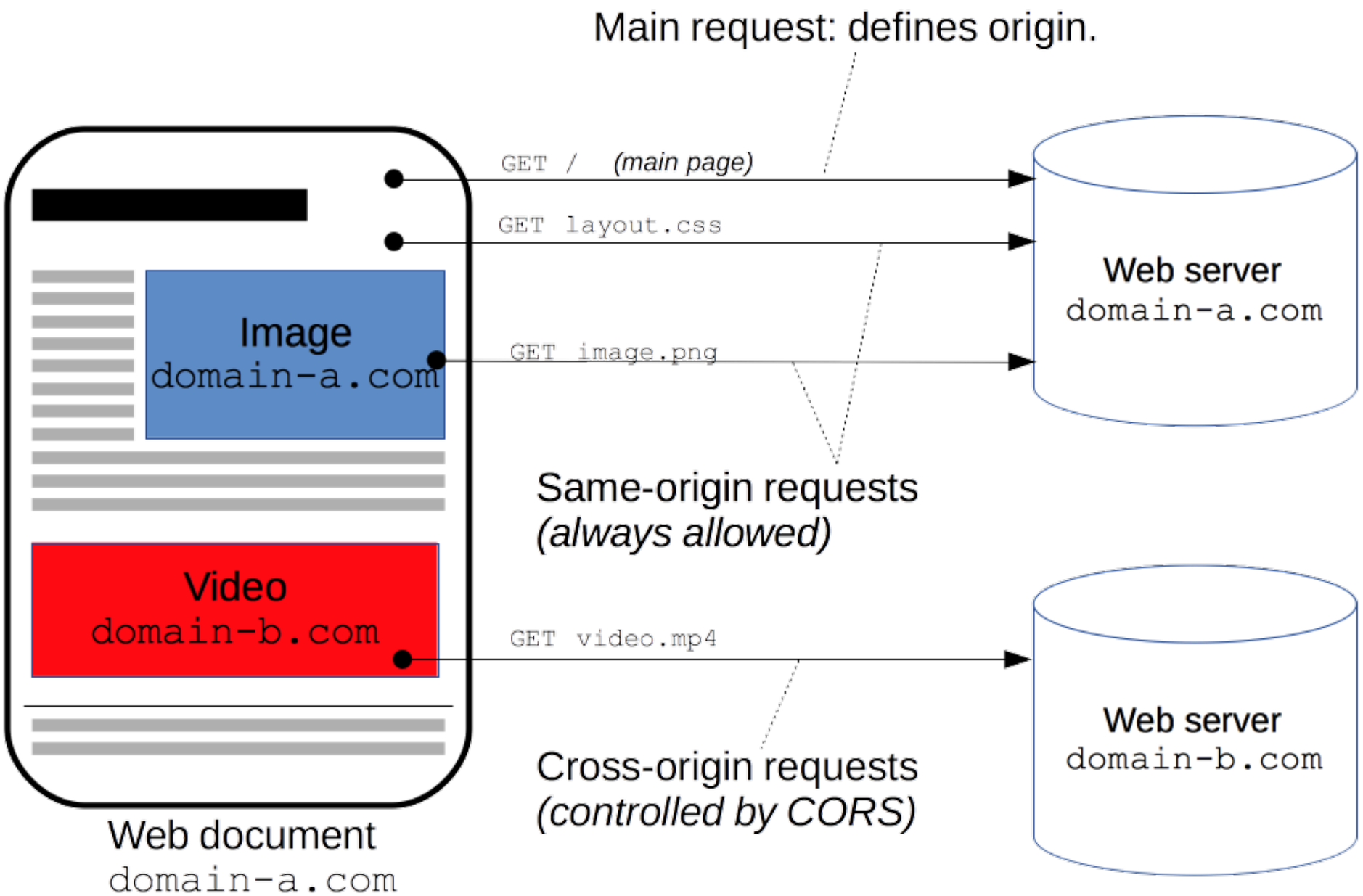
http://en.example.com:80/dir/page.html

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

Readings for next time

- Intro to microservices
  - https://www.martinfowler.com/articles/microservices.html