WebSockets

Yeah, about that whole “stateless” thing…

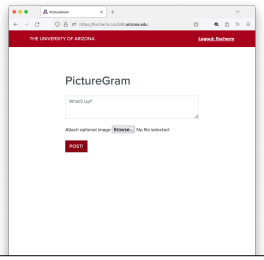
WebSockets

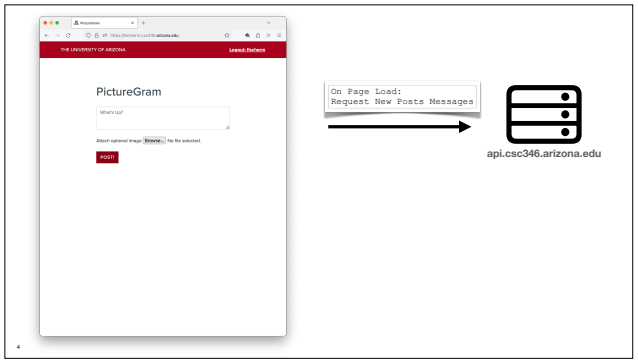
Sometimes you just need a constant connection

- Recall that the HTTP protocol is stateless.
  - Each HTTP request is separate and isolated from any other ones.
  - We’ve repeated this more than a few times this semester 😅
- What are some of the use cases where a stateless network model starts to fail?

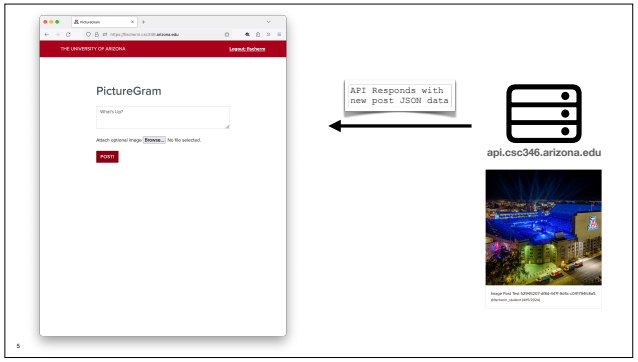
Chat

How does our Chat App get new chat messages?

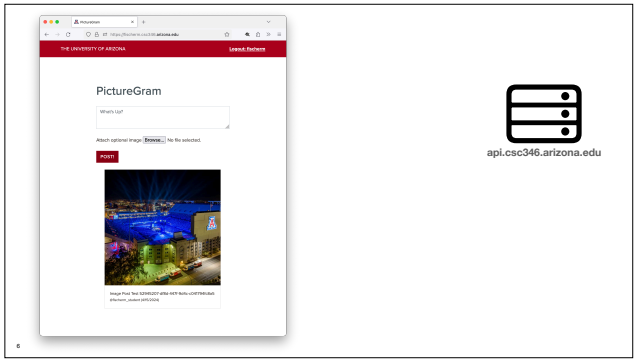



PictureGram
What's Up?
Attach optional image: Browse... No file selected.
POST!
On Page Load:
Request New Posts Messages
api.csc346.arizona.edu

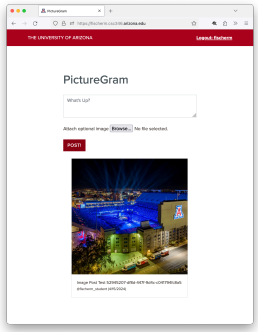
4


PictureGram
What's Up?
Attach optional image: Browse... No file selected.
POST!
API Responds with
new post JSON data
api.csc346.arizona.edu

5


PictureGram
What's Up?
Attach optional image: Browse... No file selected.
POST!
api.csc346.arizona.edu

6



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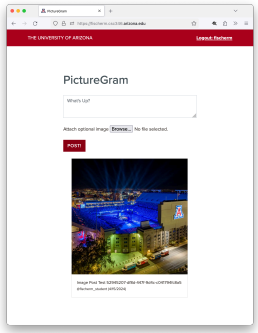
- Now What?
- If new messages are posted by someone else, how does this browser get them?
- Currently you have to reload the page

7



Polling

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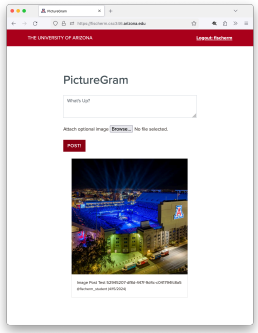
- A common approach is known as polling
- The browser checks with the API on a timer and asks for new chat messages

8




```
setTimeout( () => {
  loadPosts(newestPostTimestamp, null)
},10000)
```

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- The `setTimeout()` function will call the first argument at an interval specified in the second argument
- Here the second argument is 10000ms, so every 10 seconds the `loadChats(...)` function is called

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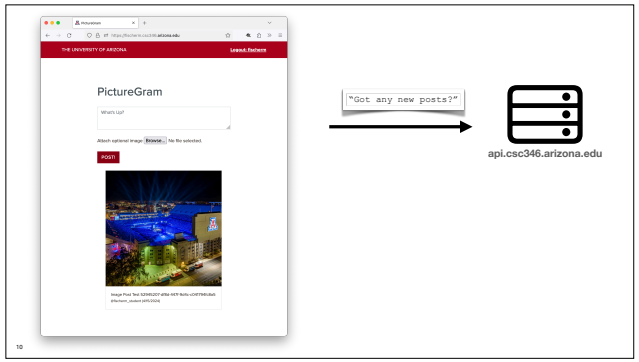
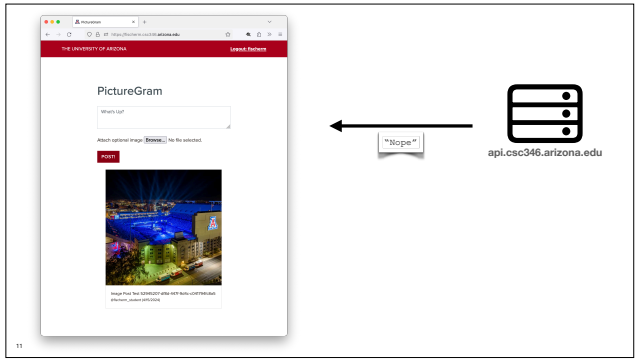
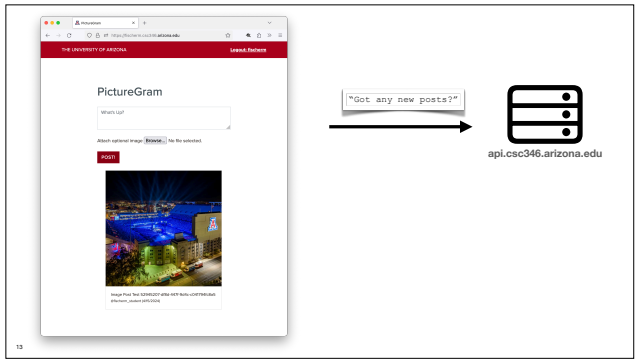
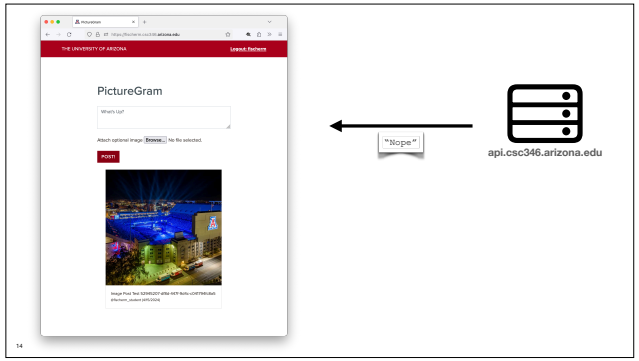

PictureGram
What's Up?
Attach optional image: Browse... No file selected.
POST!
"Got any new posts?"
api.csc346.arizona.edu
10

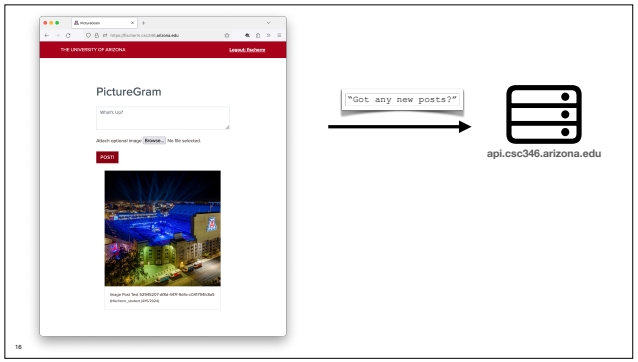

PictureGram
What's Up?
Attach optional image: Browse... No file selected.
POST!
"Nope"
api.csc346.arizona.edu
11


10
SECONDS
LATER

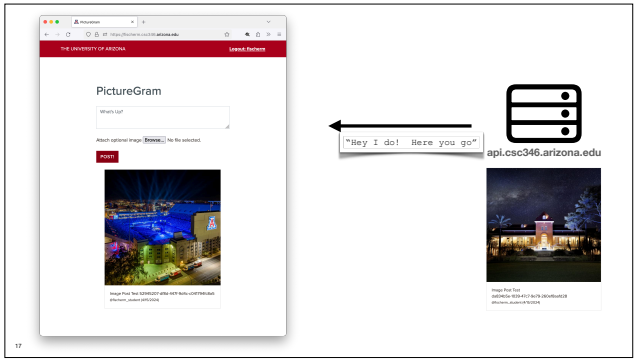

THE UNIVERSITY OF ARIZONA
Logout: fischerv
PictureGram
What's Up?
Attach optional image: Browse... No file selected.
POST!
"Got any new posts?"
api.csc346.arizona.edu
13


THE UNIVERSITY OF ARIZONA
Logout: fischerv
PictureGram
What's Up?
Attach optional image: Browse... No file selected.
POST!
"Nope"
api.csc346.arizona.edu
14

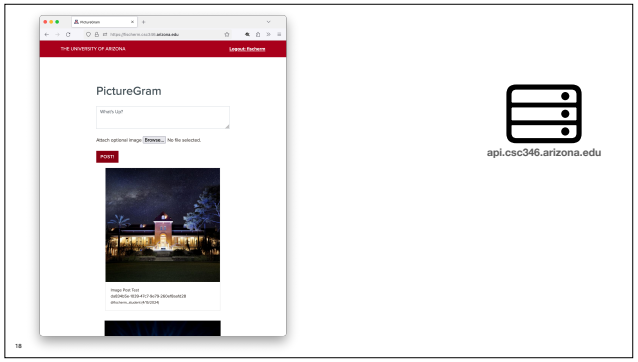

10
SECONDS
LATER


THE UNIVERSITY OF ARIZONA
Logout: fischerm
PictureGram
What's Up?
Attach optional image: Browse... No file selected.
POST!
"Got any new posts?"
api.csc346.arizona.edu

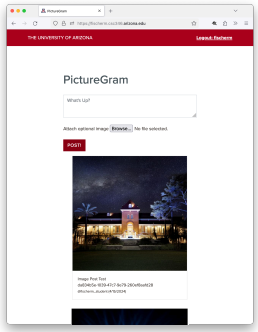
16


THE UNIVERSITY OF ARIZONA
Logout: fischerm
PictureGram
What's Up?
Attach optional image: Browse... No file selected.
POST!
"Hey I do! Here you go"
api.csc346.arizona.edu

17


THE UNIVERSITY OF ARIZONA
Logout: fischerm
PictureGram
What's Up?
Attach optional image: Browse... No file selected.
POST!
api.csc346.arizona.edu

18



Polling

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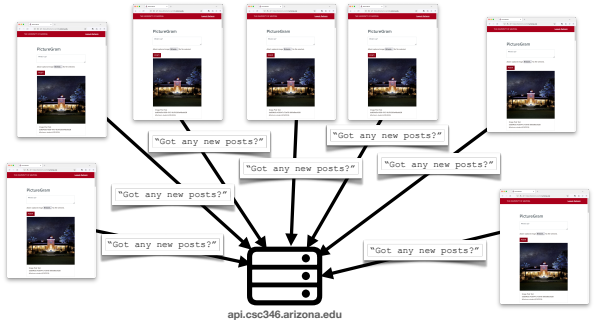
- This works OK for small numbers of infrequent polling
- What happens when there are many clients?

19



20

Polling

Has its downsides

- Polling requires each client to constantly ask the API for new data
- Short polling intervals can overwhelm the API host with incoming requests for updates
- Long polling intervals can result in significant delay getting new data out to clients
  - The Host may know there's a new message, but it has to wait for a client to ask for it

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WebSockets

All that is old is new again

- What if we could establish a long-lived network connection between the client and the host?
- This is what WebSockets does

WebSockets

- So are WebSockets just regular TCP Sockets?
- Spoiler, No
- Conceptually, WebSockets and TCP Sockets have similar goals
  - Support Long-Lived Connections
  - Two-Way Communication
  - Not Request Based
- However they are not related technologically
  - WebSockets are an extension to the HTTP Protocol that runs on top of a TCP Socket

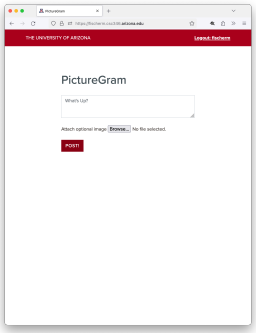
WebSockets

Challenges

- Low-level socket programming is hard
- Many network situations only permit “web” traffic over ports 80 or 443
- Session and state information about web application logins are already using Cookies, we don’t want a new way of handling state
- Security and encryption are already established for HTTPS communications, developing an additional model would be anoying

WebSockets
Solutions

- Implement a new type of HTTP request
- New request creates a “socket” inside an HTTP request
- Can stay open forever
- Bi-directional comm (not request/response)
- Relatively inexpensive (server memory, network)
- Uses standard HTTP mechanisms for encryption, cookies, etc.
  - Uses standard HTTP/HTTPS ports




```
GET /chat HTTP/1.1
Host: chat-api.csc346.arizona.edu
Upgrade: websocket
Connection: Upgrade
Sec-WebSocket-Key: dGhlIHNhbXBsZSBub25jZQ==
Sec-WebSocket-Version: 13
```

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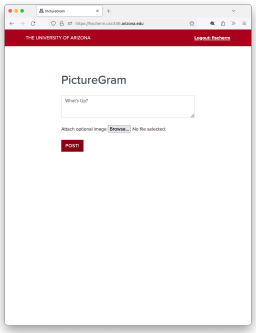
- A regular HTTP request initiates the WebSocket handshake
- Additional headers are sent, telling the host that the client would like to upgrade this connection to a WebSocket
- Passes along a client key
  - This is just an identifier, not a cryptographic key




```
HTTP/1.1 101 Switching Protocols
Upgrade: websocket
Connection: Upgrade
Sec-WebSocket-Accept: s3pPLMBiTxaQ9kYGzzhZRbK+xOo=
```

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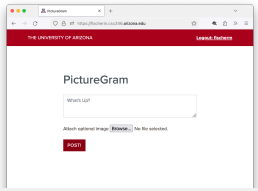
- If the server supports WebSockets, it responds with the correct headers
- The Sec-WebSocket-Accept response header is calculated in a seemingly overcomplicated way, but exists so that it's obvious to the client whether the server supports WebSockets




```
HTTP/1.1 101 Switching Protocols
Upgrade: websocket
Connection: Upgrade
Sec-WebSocket-Accept: s3pPLMBiTxaQ9kYGzzhZRbK+xOo=
```

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- The `Sec-WebSocket-Accept` header is important in that the server must derive it from the `Sec-WebSocket-Key` that the client sent to it.
- To get it, concatenate the client's `Sec-WebSocket-Key` and the string `"258EAFA5-E914-47DA-95CA-C5AB0DC85B11"` together, take the SHA-1 hash of the result, and return the base64 encoding of that hash.
- You likely will never have to do this unless you want to implement a WebSockets compliant HTTP server. Still useful to know that it's part of the handshake.

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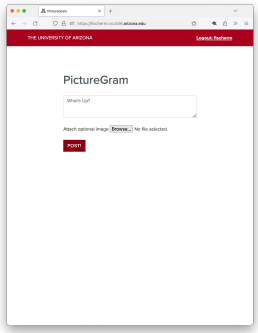

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- From that point on, there is a persistent connection between the client and host
- Connection remains open until one side or the other explicitly closes it
- Data can be sent and initiation in either direction by either the client or the host at any time
- Data transfer is now a binary format

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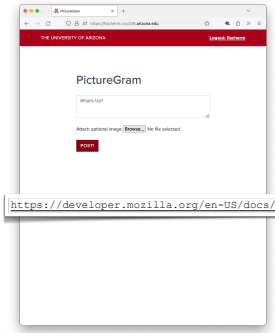

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`https://developer.mozilla.org/en-US/docs/Web/API/WebSockets_API/Writing_WebSocket_servers`

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WebSockets
Using with JavaScript

- Handshake details are handled by the browser
- Presents a JavaScript interface to us: **`new WebSocket(…)`**

```
const apiHost = "wss://chat-api.csc346.arizona.edu/chats"
const exampleSocket = new WebSocket(apiHost)
```


WebSockets
Using with JavaScript

- New Protocol prefix: `ws://` and `wss://`
  - `ws://` kicks off a handshake over `http://`
  - `wss://` kicks off the handshake over `https://`

```
const apiHost = "wss://chat-api.csc346.arizona.edu/chats"
const exampleSocket = new WebSocket(apiHost)
```


WebSockets
Sending messages to the server

```
const apiHost = "wss://chat-api.csc346.arizona.edu/chats"
const exampleSocket = new WebSocket(apiHost)

exampleSocket.send("Message to the server")

data = {
  "type": "newchat",
  "message": "Here's a new chat message",
  "user": "fischerm"
}

exampleSocket.send(data)
```

WebSockets

Listening for incoming messages

```
const apiHost = "wss://chat-api.csc346.arizona.edu/chats"
const exampleSocket = new WebSocket(apiHost)

exampleSocket.addEventListener('message', (event) => {
    console.log('Message from server ', event.data);
});
```


WebSockets

MTG Card Demo

WebSockets

From the Server's Side

WebSockets
Server Responsibilities

- The server side has a few duties
  - Accept HTTP Connections and look for the `Upgrade: websocket` and `Connection: Upgrade` headers
  - Calculate the correct `Sec-WebSocket-Accept` response value
  - Keep the WebSocket open
  - Keep track of all open WebSockets, and allow an API to send messages to specific clients

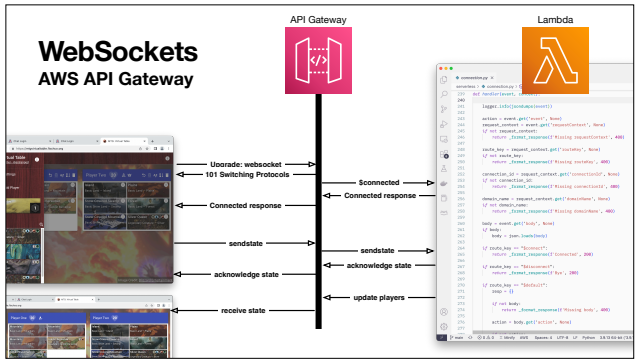
WebSockets
AWS API Gateway

- Most Cloud Providers have a managed service for WebSockets
- AWS API Gateway supports multiple API specifications
  - REST
  - Basic HTTP
  - WebSockets

```
https://docs.aws.amazon.com/apigateway/latest/developerguide/apigateway-websocket-api-overview.html
```


WebSockets
AWS API Gateway

- API Gateway takes care of all the protocol level work associated with WebSockets
  - Accepts and Upgrades WebSocket connections
  - Calculates `Sec-WebSocket-Accept` responses
  - Keeps Socket connections open
  - Assigns Connection IDs to each open WebSocket and tracks activity
  - Sends activity to a backend processor, ie Lambda



WebSockets

Server Code Demo