CS 338: Graphical User Interfaces

Lecture 4-2:
Web Development III

Web Dev Continued

- We've already covered (briefly)…
  - HTML, CSS, JavaScript, jQuery, Bootstrap
- This week, at a higher level, we'll covered (briefly) how to pass information from the server (Flask) to the interface (JavaScript → HTML)

Flask

- A Python-based "microframework" for web development
  - "Micro" in the sense that it tries to provide only the core functionality for a web server, while allowing you to add other components as needed (e.g., a database)
- We will assume Python 3.X in our work (though Flask is compatible with 2.X)
- You've (hopefully!) gotten this installed already as part of Assignment 0

Flask

- Server application
  - A minimal server application might look like this:

```
from flask import Flask

app = Flask(__name__)

@app.route('/')
def hello_world():
    return 'Hello, World!'
```

Flask

- Server application
  - To run the server…
  - Flask docs mention using the FLASK_APP shell variable in conjunction with the **flask** shell command
  - We will use an alternative approach:
    - Add code to start the server in the application…

```
if __name__ == "__main__":
    app.run(host='127.0.0.1', port=8080, debug=True)
```

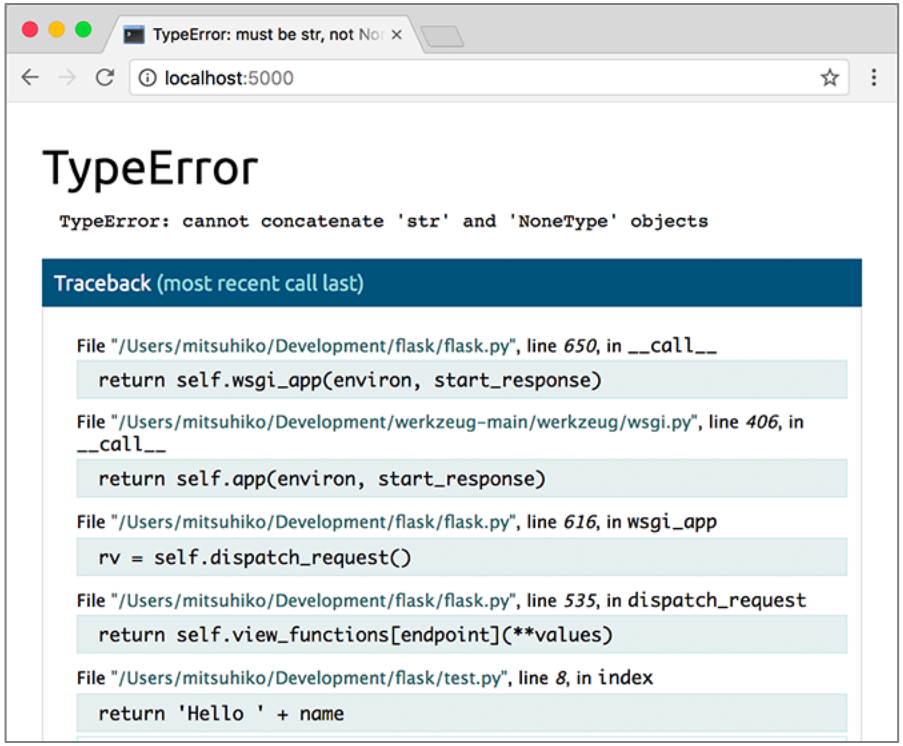
    - … and execute your Python file in the usual way

```
> python3 run.py
```

    - Now point your browser to http://127.0.0.1:8080 and voila!

Flask

- Server application
  - Note that we set "debug=True" in our server
  - This conveniently gives us trace information for errors…



… however (!!) …

Attention
The interactive debugger … allows the execution of arbitrary code. This makes it a major security risk and therefore it **must never be used on production machines.**

Flask

- Routing
  - Typically you would use different code to render different URLs for your site
  - Flask allows for **routing** decorators that specify the URL

```
@app.route('/')
def index():
    return 'Index Page'

@app.route('/hello')
def hello():
    return 'Hello, World'
```

Flask

- Static files
  - Web sites normally have simple static files that you just want to serve to the front end (e.g., CSS, JS, images)
  - Rather than do any fancy URL routing, Flask allows a simple addition to the app specification:

```
app = Flask(__name__, static_folder='public', static_url_path='')
```

- Put your files in **/public/<path>** ,
  Use the URL **/<path>**
  - E.g., a file at /public/img/photo.jpg
    can be loaded at http://127.0.0.1:8080/img/photo.jpg

Flask

- Templates
  - Basically HTML, but include both static HTML *and* special template syntax for dynamic content
  - Provide a way to re-use HTML/code consistently across a web site (or parts of one)
  - Provide a way to use back-end data (e.g., a database) to build web pages dynamically
  - There are various options out there for template syntax… Flask uses a framework called Jinja for its syntax
    - Special markers "{% … %}" and "{{ … }}" have special meaning
    - Other systems like Django, Express.js modules use the same idea

Flask

- Templates
  - One common use case: base + page HTML/template
  - Base template:

```
<html>
<head>
    <title>My Site - {% block title %}{% endblock %}</title>
    ...
</head>
<body>
  <nav>
    ...
  </nav>
  <section class="content">
    {% block content %}{% endblock %}
  </section>
</body>
</html>
```

Flask

- Templates
  - One common use case: base + page HTML/template
  - Page template that uses the base template:

```
{% extends 'base.html' %}

{% block title %}
  About Us
{% endblock %}

{% block content %}
  <h1>About Us</h1>
  <p>...</p>
{% endblock %}
```

  - And then to render the template in your routing function:

```
@app.route('/')
def index():
    return render_template('index.html')
```

Flask

- Templates
  - Another common use case: passing data to a template
  - Routing function passes a variable as a keyword arg…

```
@app.route('/')
def index():
    return render_template('index.html', message="Hello World!")
```

  - … and the template uses the variable with "{{ … }}"

```
<h1>{{ message }}</h1>
```

  - There are lots of extra features, like auto-escaping, filtering, formatting, etc.

Flask

- Templates
  - Loops can iterate over lists of data elements:

```python
@app.route('/about')
def about():
    data = {
        'related': [
            {'name': 'Rent A Goat', 'url': 'http://rentagoat.com'},
            {'name': 'We Rent Goats', 'url': 'http://werentgoats.com'},
            {'name': 'Goat Yoga', 'url': 'https://goatyoga.net/'}
        ]
    }
    return render_template('about.html', data=data)
```

```
<ul>
    {% for site in data.related %}
    <li><a href="{{ site.url }}">{{ site.name }}</a></li>
    {% endfor %}
</ul>
```

Flask

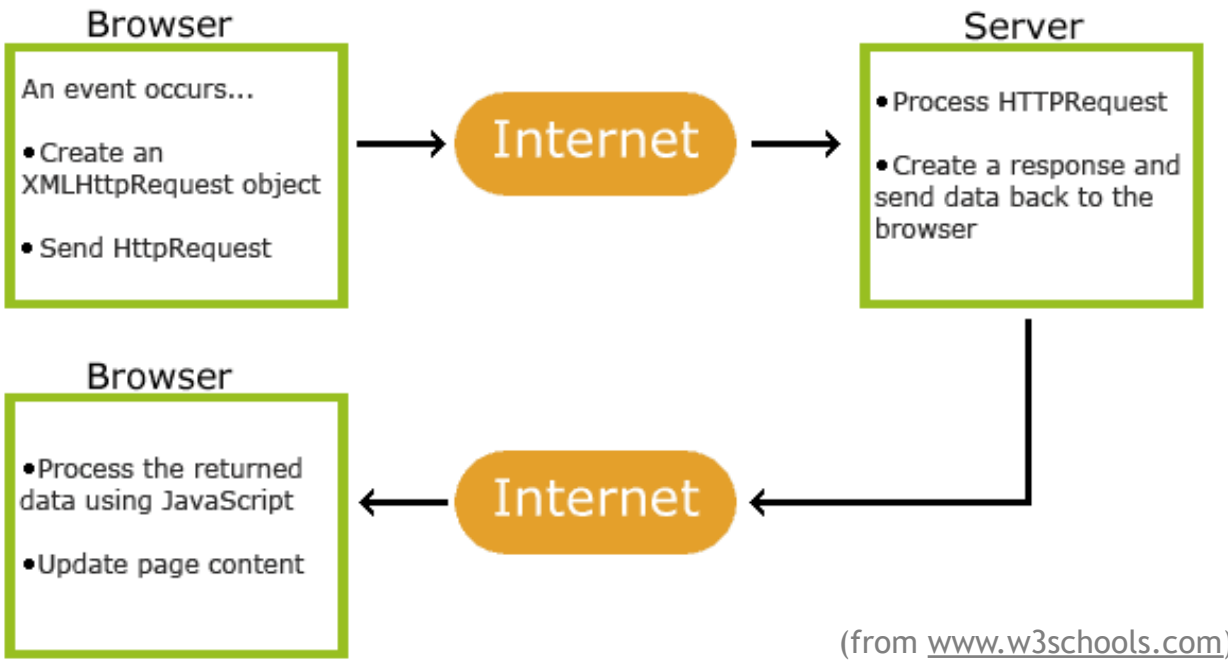
- This covers communication in one direction
  - When the user does something, we usually need to…
    - Store this action somehow in a back-end database
    - Reflect the change in the
  - How does this info get to the server?

AJAX

- AJAX = Asynchronous JavaScript And XML
- The acronym is, unfortunately, tied to two specific languages, but that's not the important part
  - In fact, many applications don't even use XML (they use JSON instead)
- What's important is the technique of passing information dynamically, front <–> back end
- The user stays on the same page the whole time; AJAX + JavaScript handle all the necessary changes to the page

AJAX

- One view of the AJAX process:



(from www.w3schools.com)

Browser: jQuery AJAX

- The "pure" JavaScript involves creating and passing HTTP objects directly
- You could do this — but more common today is to use a convenient higher-level API
- jQuery actually provides a number of methods to send data to the server and then receive a response
  - Not at page load! (e.g., via templates)
  - But rather, after the page has loaded, get more data
  - This is typical for many web pages today
    - Like when you see that "Loading…" message for a table/etc.

Browser: jQuery AJAX

- (One way to see how much JavaScript/AJAX action in a web site: turn off JavaScript and load it…)
  - http://www.drexel.edu
  - http://www.philly.com

Browser: jQuery AJAX

- jQuery **get** method

```
$.get(URL, data, function(data), dataType)
```

  - URL (required): where to ask for information
  - data (optional): any data to pass to the server, if needed
  - function (optional): fn to run if/when server call succeeds
  - dataType (optional): “json”, “xml”, etc. (auto by default)

- Typical pattern:

```
$.get("/api/test", {clicked: "yes"}, function(data) {
  alert("Data from server: " + data);
});
```

Browser <-> Server Data

- The data sent between browser and server can be "packaged" using different formats
- Arguably the most common format today is JSON
- JSON = JavaScript Object Notation, which includes:
  - String, number, boolean, null
  - Arrays
  - JSON Object (recursively) with keys and values

```
{"employees":[
  { "firstName":"John", "lastName":"Doe" },
  { "firstName":"Anna", "lastName":"Smith" },
  { "firstName":"Peter", "lastName":"Jones" }
]}
```

Server: AJAX Handler

- When the browser makes a request to a server URL (e.g., "`/api/test`"), the server responds with data
- Recall that Flask provides our server, and has routing specifications for different URLs
- Let's assume that:
  - All AJAX calls are served by URLs that start with "`/api/`"
  - The server responds to all AJAX calls with JSON

Server: AJAX Handler

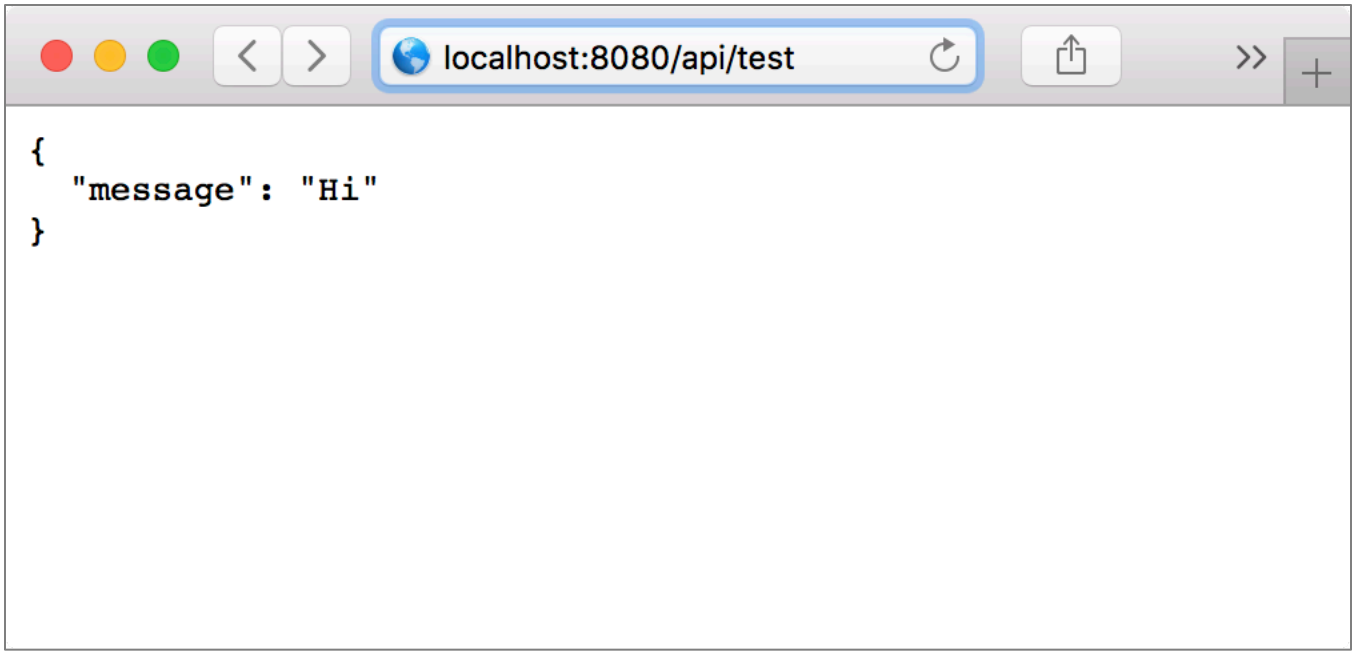
- Flask handles an AJAX call like any other, except that it should return JSON (instead of HTML)
- We can simply add to our list of routing functions:

```
@app.route('/')
def index():
    return 'Index Page'

@app.route('/hello')
def hello():
    return 'Hello, World'

@app.route('/api/test')
def api_test():
    return jsonify({'message': 'Hi'})
```

jsonify() packages the data into JSON

Server: AJAX Handler

- To test the handler, you can point your browser to the AJAX URL and see what it returns!



Server: AJAX Handler

- When data is passed to the server, you'll need to extract the information from the **request** object
  - jQuery call on the browser:

```
$.get("/api/test", {clicked: "yes"}, function(data) {
  alert("Data from server: " + data);
});
```

  - Flask handler on the server:

```
@app.route('/api/test')
def api_test():
    clicked = request.args.get('clicked', default='no')
    return jsonify({'message': 'User clicked ' + clicked})
```

Gets the named argument from the request object

Default applies if argument is not supplied

Server: AJAX Handler

- Again, you can check the handler in your browser
- Arguments must be specified in URL format

Browser: jQuery AJAX

- Ok, now back to the browser…
- The data from the server is returned to the success function supplied to the **get** method:

```
$.get("/api/test", {clicked: "yes"}, function(data) {
  alert("Data from server: " + data);
});
```

- Here, we're just showing the data in an alert
- But normally, we would use the data to build relevant HTML within the web page
  - That is, we use jQuery to construct DOM elements and populate the page with the new elements

Example #1

- Let's return to our Goat Pasture web site and build a dynamic, AJAX-y "Adopt a Goat" page
- We'll provide a list of goats for adoption, and the user can click one to adopt it
- Importantly, the user's actions need to be reflected in a central database on the back-end server
  - We'd like a simple database that interfaces easily with Python but has plenty of powerful features
  - SQLite gives us more than enough features for this course
  - Of course, you could substitute a more powerful DB

Example #1

- SQLite table

```
sqlite3 goats.db

CREATE TABLE goats (
 uid INTEGER PRIMARY KEY,
 name TEXT NOT NULL,
 age INTEGER,
 img TEXT
);

.mode csv
.import dev/data.csv goats
```

- Data

```
1,Billy,3,goat1.jpg
2,Doc,5,goat2.jpg
3,Sarah,4,goat3.jpg
4,Kid,2,goat4.jpg
5,Buffy,3,goat5.jpg
6,Smiles,4,goat6.jpg
7,Einstein,7,goat7.jpg
8,Frank Beard,6,goat8.jpg
9,LuLu,1,goat9.jpg
10,Pegasus,4,goat10.jpg
11,Zeus,12,goat11.jpg
12,Willow,2,goat12.jpg
13,Big Al,7,goat13.jpg
```

Example #1

- Python Database class

```
class Database:

    def __init__(self):
        self.conn = sqlite3.connect(SQLITE_PATH)

    def execute(self, sql, parameters=[]):
        c = self.conn.cursor()
        c.execute(sql, parameters)
        return c.fetchall()

    def get_goats(self, n, offset):
        data = self.execute(
            'SELECT * FROM goats ORDER BY uid ASC LIMIT ? OFFSET ?', [n, offset])
        return [{
            'uid': d[0],
            'name': d[1],
            'age': d[2],
            'img': d[3]
        } for d in data]

    def close(self):
        self.conn.close()
```

Example #1

- Python Flask database + routing code

```
def get_db():
    db = getattr(g, '_database', None)
    if db is None:
        db = Database()
    return db


@app.teardown_appcontext
def close_connection(exception):
    db = getattr(g, '_database', None)
    if db is not None:
        db.close()


@app.route('/api/goats')
def api_goats():
    n = request.args.get('n', default=6)
    offset = request.args.get('offset', default=0)
    goats = get_db().get_goats(n, offset)
    return jsonify(goats)
```

  - Note that database must be stored in global **g** variable

Example #1

- Testing the API handler

Example #1

- HTML

```
<h1>Adopt a Goat</h1>

<p>
  Please see our awesome goats below and
  adopt one today!
</p>

<div id="cards" class="container">

</div>
```

Example #1

- JavaScript

```
let goatsPerColumn = 3;
var goatsPerPage = 3;


// updateCards() on next slide


$(function () {
    $.get("api/goats", { n: goatsPerPage, offset: 0 }, function (goats) {
        updateCards(goats);
    });
});
```

Example #1

- JavaScript

```
function updateCards(goats) {
    for (var i = 0; i < goats.length; i++) {
        let goat = goats[i];
        let card = $('<div>').addClass('card')
            .append(
                $('<img>').addClass('card-img-top').attr('src', '/img/goats/' + goat.img)
            ).append(
                $('<p>').addClass('card-body')
                    .append(
                        $('<h5>').addClass('card-title').text(goat.name)
                    ).append(
                        $('<p>').addClass('card-text').text(goat.age + ' years old')
                    ).append(
                        $('<a>').addClass('btn btn-primary').text('Adopt')
                    )
            );
        if (i % goatsPerColumn == 0)
            $('#cards').append(
                $('<div>').addClass('card-deck')
            );
        $('#cards .card-deck').last().append(card);
    }
}
```

Example #1


Home
About Us
Goat School
Adopt a Goat
Account
Adopt a Goat
Please see our awesome goats below and adopt one today!
Billy
3 years old
Adopt
Doc
5 years old
Adopt
Sarah
4 years old
Adopt

Example #1

- Ok, not bad.
- We're dynamically receiving the first 3 goats from the server and building the card deck
- However…
  - When we click "Adopt", nothing happens!
    How can we alter the page to reflect the change?
    More importantly, how can we tell the server?!?
  - We can only see 3 goats!
    What about the next 3? and the next 3? and …

Example #2

- Let's handle the "Adopt" button and send a notification of adoption to the server
- JavaScript: outline

```
const goatsPerColumn = 3;
const goatsPerPage = 6;

function buildCards(goats) {
    ...
}

function loadGoats() {
    ...
}

function adoptGoat(uid, value) {
    ...
}

$(function () {
    loadGoats();
});
```

```
function buildCards(goats) {
    ...
                        $('<a>').addClass('btn btn-primary').text('Adopt')
                            .click(function () {
                                goat.adopted = goat.adopted ? 0 : 1;
                                adoptGoat(goat.uid, goat.adopted);
                            })
    ...
        if (goat.adopted)
            card.addClass('adopted');
    ...
}

function loadGoats() {
    $.get("api/goats", {
        n: goatsPerPage,
        offset: 0
    }, function (goats) {
        buildCards(goats);
    });
}

function adoptGoat(uid, value) {
    $.get("api/adopt", {
        uid: uid,
        value: value,
        n: goatsPerPage,
        offset: 0
    }, function (goats) {
        buildCards(goats);
    });
}
```

Example #2

- CSS

```
.card.adopted {
    opacity: .25;
}
```

Example #2

- Python Database class

```
class Database:
    ...

    def select(self, sql, parameters=[]):
        c = self.conn.cursor()
        c.execute(sql, parameters)
        return c.fetchall()

    def execute(self, sql, parameters=[]):
        c = self.conn.cursor()
        c.execute(sql, parameters)
        self.conn.commit()

    def get_goats(self, n, offset):
        data = self.select(
            'SELECT * FROM goats ORDER BY uid ASC LIMIT ? OFFSET ?', [n, offset])
        return [{
            'uid': d[0], 'name': d[1], 'age': d[2], 'adopted': d[3], 'image': d[4]
        } for d in data]

    def update_goat_adopted(self, uid, value):
        self.execute('UPDATE goats SET adopted=? WHERE uid=?', [value, uid])

    ...
```

Example #2

- Python Flask routing code

```
@app.route('/api/goats')
def api_goats():
    n = request.args.get('n', default=6)
    offset = request.args.get('offset', default=0)
    goats = get_db().get_goats(n, offset)
    return jsonify(goats)


@app.route('/api/adopt')
def api_adopt():
    uid = request.args.get('uid')
    value = request.args.get('value')
    get_db().update_goat_adopted(uid, value)
    return api_goats()
```

  - Note that "`/api/adopt`" also returns the list of goats, which avoids making a second AJAX call

Example #2


Home
About Us
Goat School
Adopt a Goat
Account
Adopt a Goat
Please see our awesome goats below and adopt one today!
Billy
3 years old
Adopt
Doc
5 years old
Adopt
Sarah
4 years old
Adopt

Example #2

- Summary: When the user clicks "Adopt"…
  - The browser sends a request to the server with the goat's **uid** and **adoption** value
  - The server updates the database with the adoption value
  - The server re-pulls the updated data from the database and returns this as a response
  - The browser takes this response and re-populates the cards with the new data
- All the user sees is a grayed-out card!
  - Of course, we could have done this easily with JavaScript
  - But the above method ensures that all changes are reflected in the database, which is essential for a real site

Example #3

- Unfortunately, we can still only see 3 goats at once
- Let's add **pagination** to our example
  - Pagination is ubiquitous in real web sites
  - For our example, it wouldn't be a big deal to send all the data and have JavaScript deal with it (just 13 goats!)
  - But on a real site, you might literally have millions/billions of records (e.g., Google)…
    so you need to ask the server to give you a "page" of data

Example #3

- Bootstrap provides nice HTML/CSS for pagination


```
<nav aria-label="Page navigation example">
  <ul class="pagination">
    <li class="page-item"><a class="page-link" href="#">Previous</a></li>
    <li class="page-item"><a class="page-link" href="#">1</a></li>
    <li class="page-item"><a class="page-link" href="#">2</a></li>
    <li class="page-item"><a class="page-link" href="#">3</a></li>
    <li class="page-item"><a class="page-link" href="#">Next</a></li>
  </ul>
</nav>
```

- But handling the actual pagination via JavaScript is left to the programmer (since it's data-specific)

Example #3

- HTML

```
<div id="cards" class="container">

</div>

<nav>
    <ul id="paginator" class="pagination justify-content-center">
    </ul>
</nav>
```

Example #3

- JavaScript

```
function createPageLink(text, toPage, active, disabled) {
    let link = $('<li>').addClass('page-item').append(
        $('<a>').addClass('page-link').text(text).click(function () {
            currentPage = toPage;
            loadGoats();
        })
    );
    if (active)
        link.addClass('active');
    if (disabled)
        link.addClass('disabled');
    return link;
}

function updatePagination(total) {
    let pages = Math.ceil(total / goatsPerPage);
    $('#paginator').empty().append(
        createPageLink('Previous', currentPage - 1, false, currentPage == 1)
    );
    for (var page = 1; page <= pages; page++)
        $('#paginator').append(
            createPageLink(page, page, page == currentPage, false)
        );
    $('#paginator').append(
        createPageLink('Next', currentPage + 1, false, currentPage == pages)
    );
}
```

Example #3

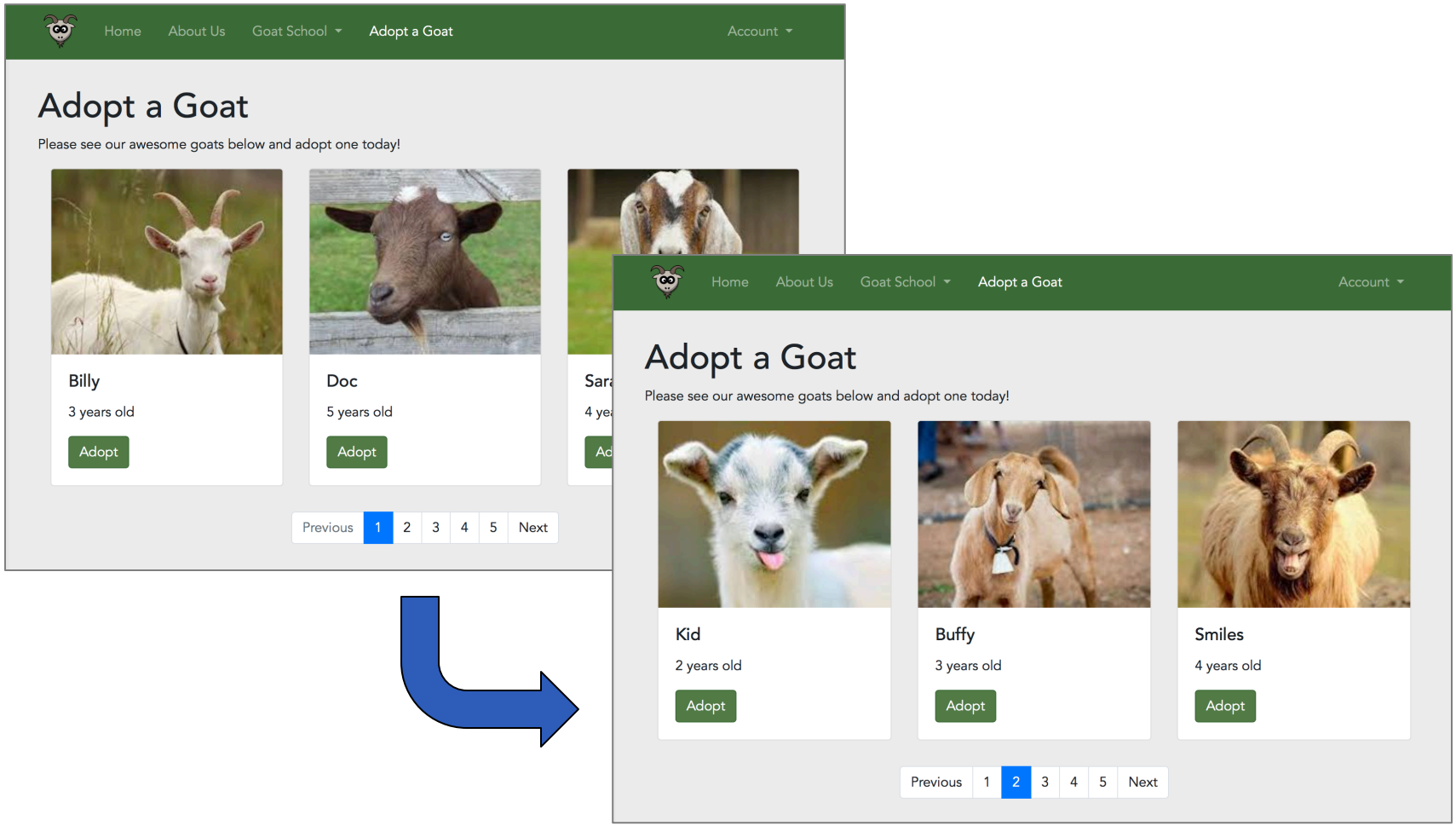
- Python Database class additions

```
def get_total_goat_count(self):
        data = self.select('SELECT COUNT(*) FROM goats')
        return data[0][0]
```

- Python Flask routing code changes

```
@app.route('/api/goats')
def api_goats():
    n = request.args.get('n', default=3)
    offset = request.args.get('offset', default=0)
    response = {
        'goats': get_db().get_goats(n, offset),
        'total': get_db().get_total_goat_count()
    }
    return jsonify(response)
```

Example #3


Home
About Us
Goat School
Adopt a Goat
Account
Adopt a Goat
Please see our awesome goats below and adopt one today!
Billy
3 years old
Adopt
Doc
5 years old
Adopt
Previous
1
2
3
4
5
Next
Home
About Us
Goat School
Adopt a Goat
Account
Adopt a Goat
Please see our awesome goats below and adopt one today!
Kid
2 years old
Adopt
Buffy
3 years old
Adopt
Smiles
4 years old
Adopt
Previous
1
2
3
4
5
Next

Final Note

- We've assumed here that we can use a GET request for all AJAX communication
- Normally, though, a GET should only be used for a "safe" request that doesn't make changes
  - E.g., we really shouldn't use it for the "adopt" function
- For any request that changes things, use POST
  - Data doesn't appear in the URL
  - Doesn't have size restriction that GET does
  - Avoids a web crawler (like google) crawling to your web site and submitting who-knows-what!

That's It

- Our intro to the various technologies…
  - HTML, CSS, JavaScript, jQuery, Bootstrap, Flask
- … gave you the basics of the front-end interface, but only a taste of the back-end server — only what was need to serve pages
- Now, we've seen a much more realistic scenario, with data being passed dynamically between the browser and the server
  - The basic ideas here can take you a long way!