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ADVANCED WEB TECHNOLOGIES
SET09103
TOPIC #06

DATA & DATASTORES

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TL/DR

Data can be at rest or in motion & exist in different forms at different times. Let's use this to our advantage by learning to store (Database), & serialise it (JSON).

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OVERVIEW

- Data Representation - Describing data structure.
- Data Transports - Telling recipients what to expect.
- Data Stores - Storing data for retrieval at scale.

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DATA DRIVEN SITES

- As we start to build more feature rich sites - we generally have more data to structure, manipulate, store, & move around:
  - Data often sent to web-apps, and retrieved from web-apps.
  - Data often stored either in filesystem or in datastores.
  - Data often manipulated within a programming language.
- So considering how data is **stored** & **transported** is important.

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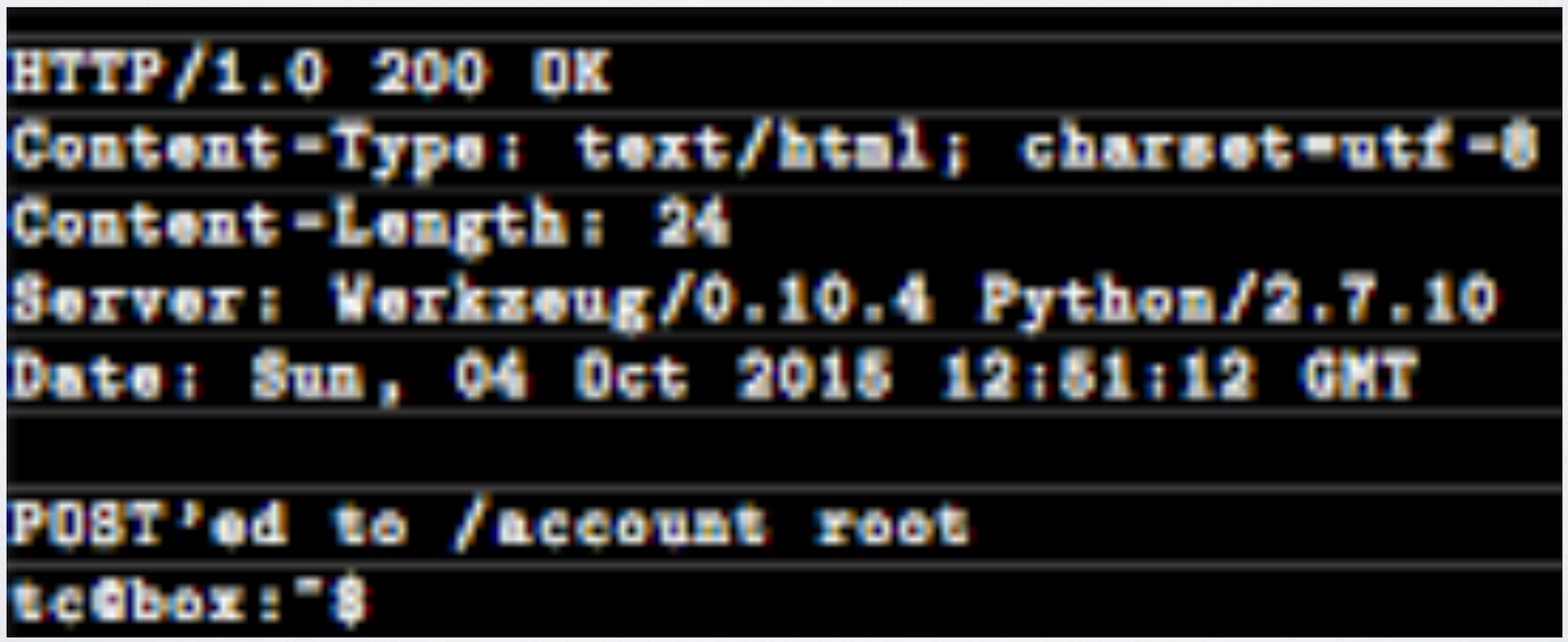
DO WE TELL THE CLIENT HOW TO USE OUR DATA?

i.e. How does the browser recognise that the content is HTML, or plain text, or JSON, or XML, or …?

MEDIA TYPES

- An HTTP header to communicate to the recipient what to expect.
- Indicate the format of the data so the recipient can make a decision about how to handle it:
  - Header, e.g. **Context-Type: text/html;** + (optional) parameter: **charset=UTF-8**
- Standardised & publicised by the Internet Assigned Numbers Authority (IANA):
  - Many examples: text/html, text/javascript, text/plain, text/xml, application/json, application/pdf, audio/mpeg,, image,/png, image/jpeg, &c.
  - NB. Originated in **M**ultipurpose **I**nternet **M**ail **E**xtensions (**MIME**) types. WHATWG discourages use of mediatype and still uses mimetype. IANA & IETF use mediatype.
  - Annoyingly the HTTP header refers to "Content-Type" rather than "Media-Type".



MEDIA TYPES

- Composed of a type, subtype and optional parameters with following format:
  - **type “/” [tree “.”] subtype [“+” suffix] *[“;” parameter]**
  - e.g. for an HTML file:
    - **text/html; charset=UTF-8**
      - **type:** text
      - **subtype:** HTML
      - **parameter:** charset=UTF-8 - indicate character encoding
- Top level names can include: application, audio, example, image, message, model, multipart, text, video
- Tree Prefix: standard, vendor (vnd), personal (prs), unregistered (x)
- Suffix: Augmentation to media type to specify underlying structure of media type, e.g. +xml. +json,+zip (& others)

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MEDIA TYPES

- We will build on this in the next topic when we bring everything together to design and build an API/Web Service.
  - HTTP Request + Verb
  - HTTP Response + Code + Mediatype + Content
    - So far: Return text/html + HTML content
    - Next topic: Return application/json + JSON content

- Interaction with a resource causes data manipulation.
- HTTP can return different types of data as a result of a request.
- HTTP can indicate the *type* of data being returned using the **mediatype** header.
- But…

WHAT DO WE MEAN BY DIFFERENT TYPES OF DATA?

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TYPES OF DATA

- How we structure & store data has a great effect on how easily we can then use, or re-use it.

- Human readable: HTML

- Human & Machine readable (machine can parse the file and reconstruct or reuse the data) but otherwise written in plain text:

  - JSON, XML, YAML, RDF, ATOM, …

- We'll concentrate on JSON (but consider XML so you know it when you see it).

JSON

- **J**ava**S**cript **O**bject **N**otation
  - If you're familiar with JavaScript & OOP then JSON should make some sense
- An open standard format
- Text-based/Human-readable
- Used to transmit data objects made of attribute-value pairs
- Originally derived from Javascript as a way to serialise Javascript objects but became popular as a language independent data format, e.g. can generate and parse JSON in many languages, e.g. Javascript (trivial), Python, and libraries available if no default standard lib support
- Described in RFC7159 & ECMA 404 (minimal, syntax only)
- Official media type is **application/json** & files are named **.json**
- **http://www.json.org/**

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```
{
  "firstName": "John",
  "lastName": "Smith",
  "isAlive": true,
  "age": 25,
  "height_cm": 167.6,
  "address": {
    "streetAddress": "21 2nd
Street",
    "city": "New York",
    "state": "NY",
    "postalCode": "10021-3100"
  },
  "phoneNumbers": [
    {
      "type": "home",
      "number": "212 555-1234"
    },
    {
      "type": "office",
      "number": "646 555-4567"
    }
  ],
  "children": [],
  "spouse": null
}
```

JSON LANGUAGE

- Plain text format - can create & edit using your text editor
- Is iteratively constructed starting with either an object {} or an array []
- Array can store a comma separated list of values
- Object can store a comma separated list of key:value pairs
- Values are objects, arrays, strings, numbers, booleans, null
- An easier way to visualise this is with railroad diagrams

```
{
  "firstName": "John",
  "lastName": "Smith",
  "isAlive": true,
  "age": 25,
  "height_cm": 167.6,
  "address": {
    "streetAddress": "21 2nd
Street",
    "city": "New York",
    "state": "NY",
    "postalCode": "10021-3100"
  },
  "phoneNumbers": [
    {
      "type": "home",
      "number": "212 555-1234"
    },
    {
      "type": "office",
      "number": "646 555-4567"
    }
  ],
  "children": [],
  "spouse": null
}
```

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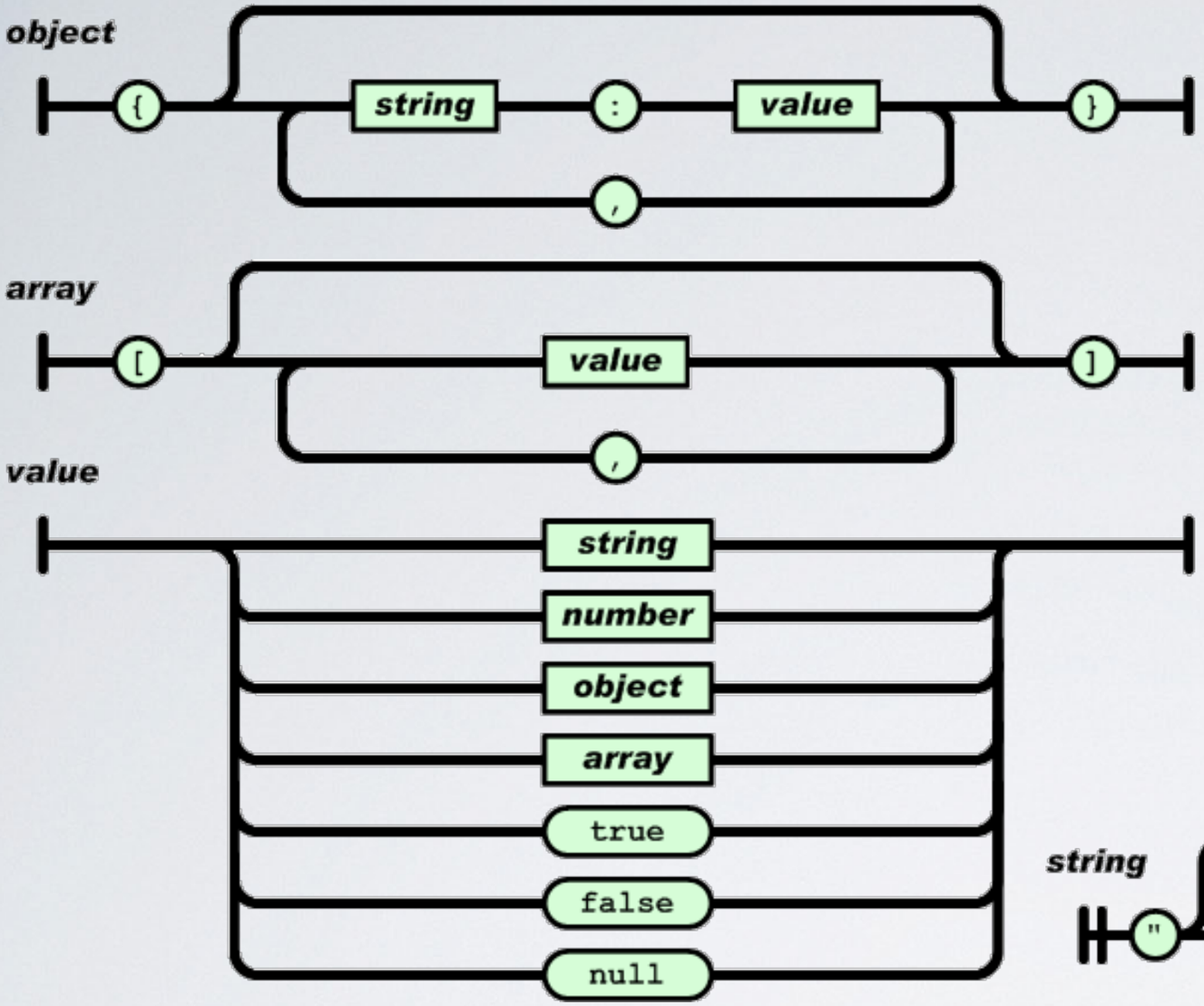
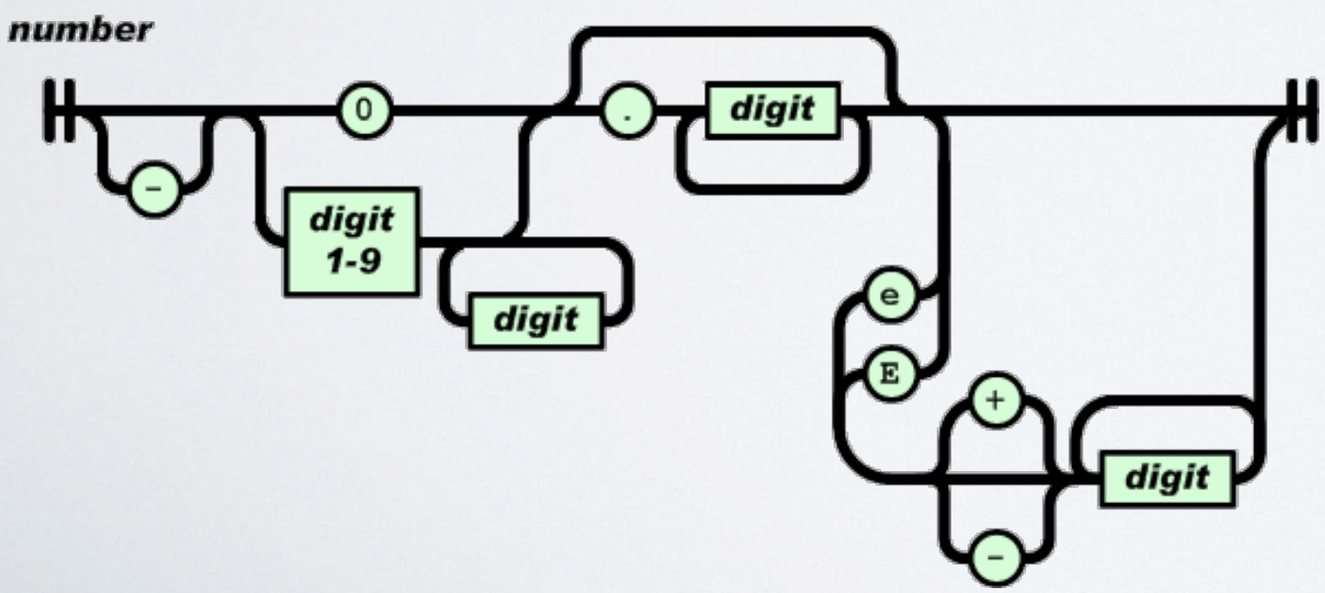
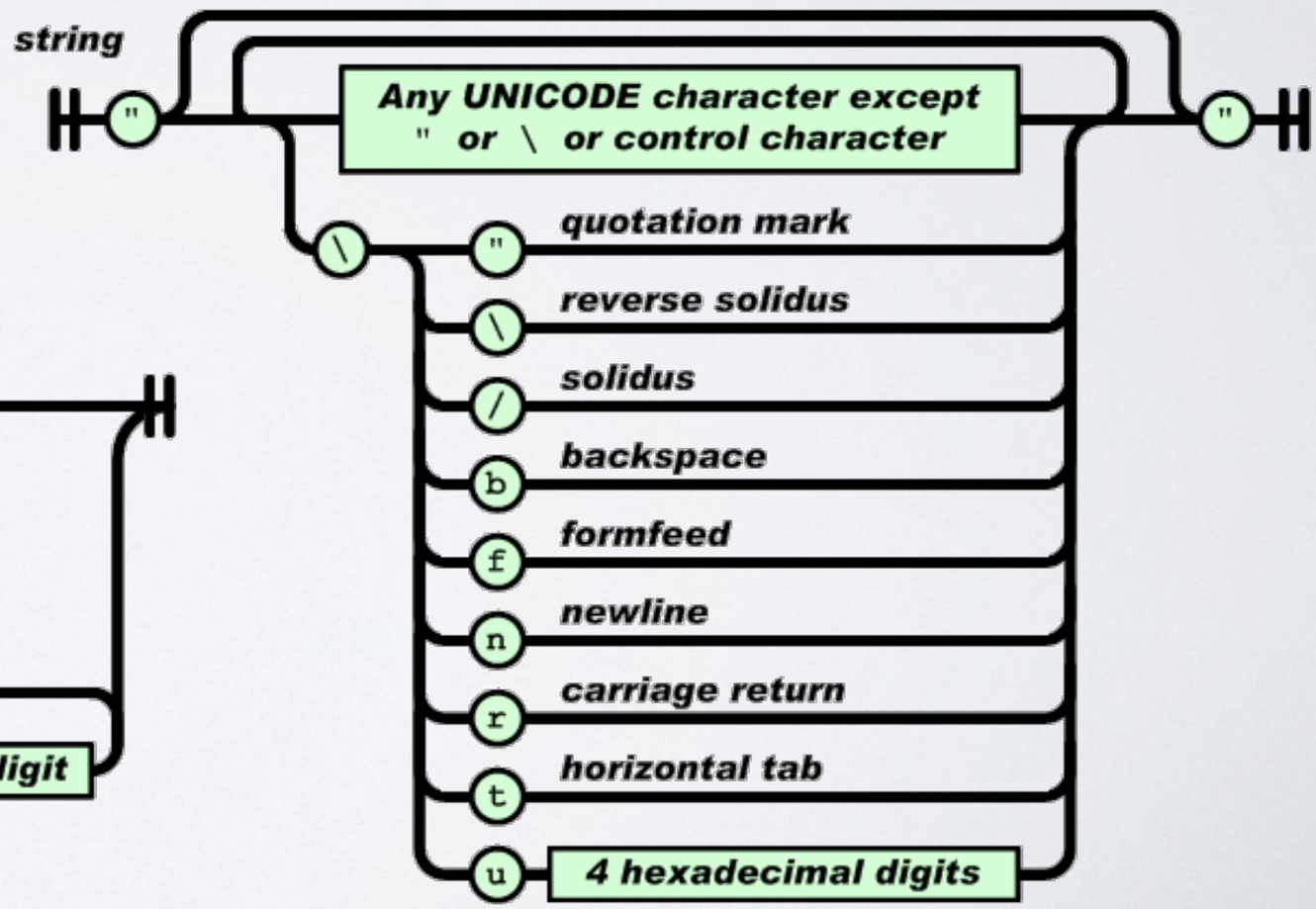
JSON RAILROAD DIAGRAMS







JSON EXAMPLE

- Datatypes:
  - Numbers
  - Strings
  - Booleans
  - Arrays []
  - Objects {}
  - null
- http://json.org/
- http://jsonlint.com/

```
{
  "firstName": "John",
  "lastName": "Smith",
  "isAlive": true,
  "age": 25,
  "height_cm": 167.6,
  "address": {
    "streetAddress": "21 2nd
Street",
    "city": "New York",
    "state": "NY",
    "postalCode": "10021-3100"
  },
  "phoneNumbers": [
    {
      "type": "home",
      "number": "212 555-1234"
    },
    {
      "type": "office",
      "number": "646 555-4567"
    }
  ],
  "children": [],
  "spouse": null
}
```

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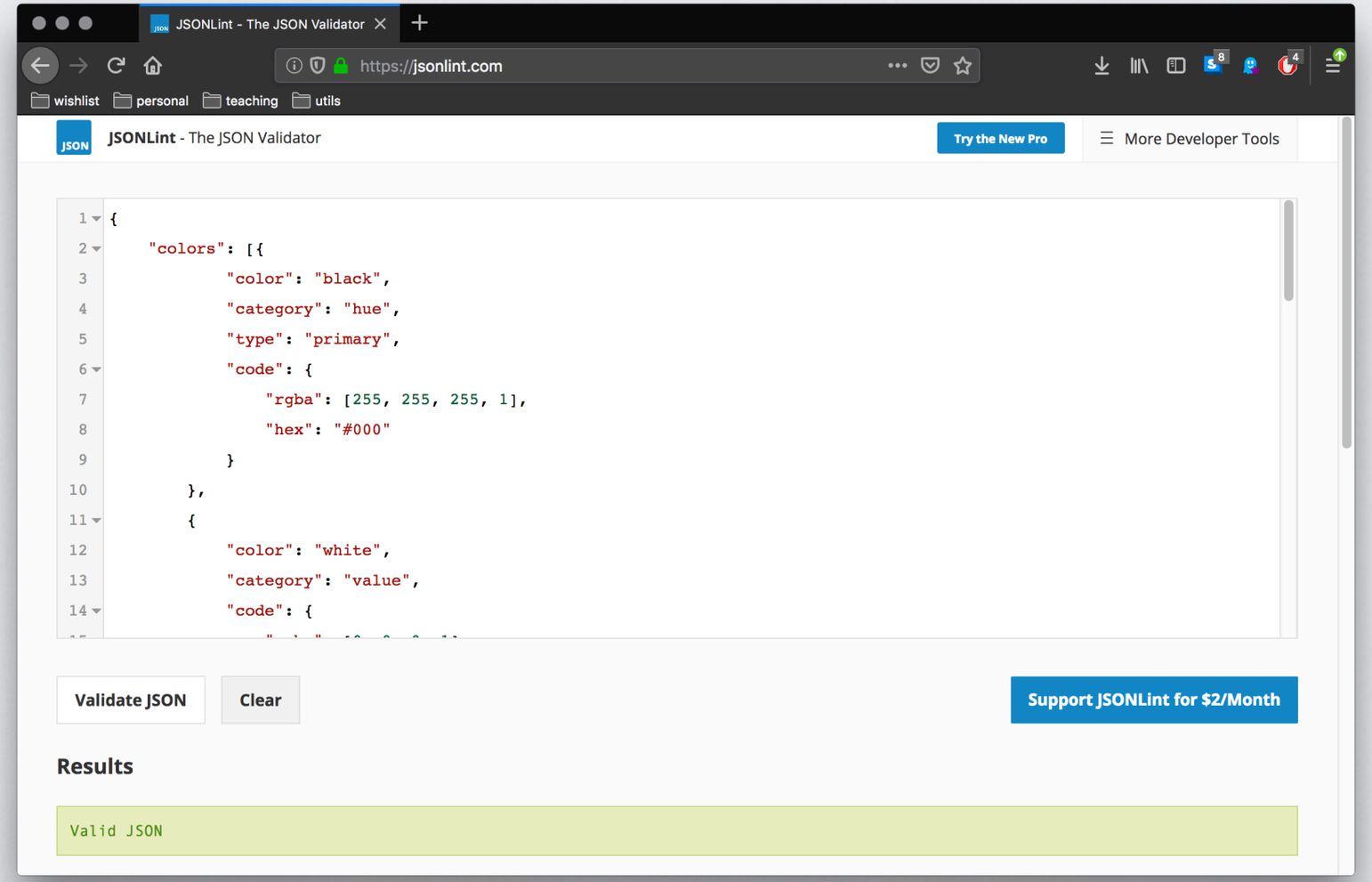
JSONLINT.COM

- A useful online tool for quickly editing & *validating* JSON files
- Edit then copy/paste to text file and save



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JSON RESOURCES

- **References**:
  - JSON Website: http://json.org/
- **Standards**:
  - RFC7159: http://tools.ietf.org/html/rfc7159
  - ECMA-404: http://www.ecma-international.org/publications/files/ECMA-ST/ECMA-404.pdf
  - JSON Schema: http://json-schema.org
- **Tools:**
  - JSONLint: http://jsonlint.com/

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XML

- XML was meant to be the *"solution to everything"*
- A free, open standard, e**X**tensible **M**arkup **L**anguage
  - Defines rules for encoding documents in a format that is human and machine readable
- Defined by W3C XML 1.0 specification (& several ancillary specifications, e.g. XML Namespaces, XPath, XSLT, XQuery)
- Design goals were for simplicity, generality, and usability
- Became widely used for representation of arbitrary data structures (like JSON has since) - and an important technology in the development of web services
- Official media type is **application/xml text/xml** & files are named **.xml**

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XML APPLICATIONS

- Many document formats use XML syntax:
  - RSS, Atom, SOAP, XHTML, MS Office/Office Open XML, Open/Libre Office Open Document Format, iWork, XMPP, .NET config files, OS X config files
- Internet data exchange (RFC 7303) - rules for constructing Internet Media Types (e.g. if building a RESTful HATEOAS based system)

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INTRODUCTION TO KEY PARTS OF XML

- Characters - An XML document is a string of **unicode** characters

- Processor & Application - Processor (often known as a **parser**) analyses markup and passes structured information to an application (NB. Specification sets out requirements for what an XML processor must be do/not do)

- Markup & Content - characters of document divided in markup and content. Generally markup strings start and end with **<** and **>** or **&** and **;**. If characters are not markup then they are content

- Start, End, & Empty Element Tags: e.g. <section> </section> <line break />

- Elements: A logical component of a document that begins with a start-tag and ends with a *matching* end-tag, e.g. <greeting>Hello Napier</greeting>

- Attributes: Within a tag, e.g. between < and >, a a tag may have key=''value'' pairs, e.g. <img src='' merchiston-campus.png'', alt=''View of the lovely buildings at Napier's Merchiston campus''>

- XML declaration: <?xml version=''1.0'' encoding=''UTF-8''?>

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WELL FORMED XML

- An XML document is a tree structure - a single "root" element contains all other "child" elements

- Contents are only properly encoded Unicode characters

- Special syntax characters (e.g. <, >, &) only used when performing markup roles unless otherwise escaped

- Start, end and empty element tags must be correctly nested with none missing or overlapping

- Element tags are case sensitive and pairs of start/end tags must match exactly

- Tag names cannot contain !"#$%&'()*+,/;<=>?@[\]^`{|}~ or space chara or start with '-' or '.' or a numeric digit

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XML SCHEMAS

- Document Type Definition (DTD)
  - Oldest, inherited from SGML, ubiquitous because in XML 1.0 standard, can be embedded within XML documents
- XML Schema (XSD)
  - Successor to DTDs, more powerful, rich datatyping, detailed constraints on XML logical structure, Based on XML so can be processed by ordinary XML tools

```xml
<person>
  <firstName>John</firstName>
  <lastName>Smith</lastName>
  <age>25</age>
  <address>
    <streetAddress>21 2nd Street</streetAddress>
    <city>New York</city>
    <state>NY</state>
    <postalCode>10021</postalCode>
  </address>
  <phoneNumbers>
    <phoneNumber>
      <type>home</type>
      <number>212 555-1234</number>
    </phoneNumber>
    <phoneNumber>
      <type>fax</type>
      <number>646 555-4567</number>
    </phoneNumber>
  </phoneNumbers>
  <gender>
    <type>male</type>
  </gender>
</person>
```

```xml
<person firstName="John" lastName="Smith" age="25">
  <address streetAddress="21 2nd Street" city="New York"
state="NY" postalCode="10021" />
  <phoneNumbers>
     <phoneNumber type="home" number="212 555-1234"/>
     <phoneNumber type="fax"  number="646 555-4567"/>
  </phoneNumbers>
  <gender type="male"/>
</person>
```

```json
{
  "firstName": "John",
  "lastName": "Smith",
  "isAlive": true,
  "age": 25,
  "height_cm": 167.6,
  "address": {
    "streetAddress": "21 2nd
Street",
    "city": "New York",
    "state": "NY",
    "postalCode": "10021-3100"
  },
  "phoneNumbers": [
    {
      "type": "home",
      "number": "212 555-1234"
    },
    {
      "type": "office",
      "number": "646 555-4567"
    }
  ],
  "children": [],
  "spouse": null
}
```

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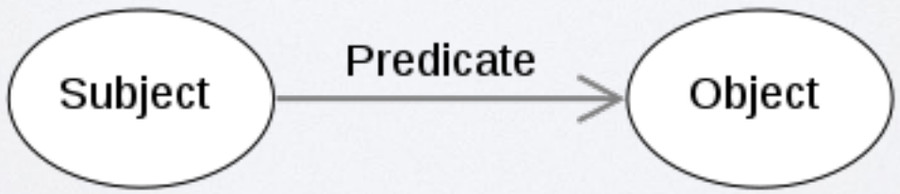
RDF

- Resource Description Framework
- Started as a data model for metadata
- Has become a *de facto* information modelling language - simplest way to define a binary relationship
- Doesn't have a single syntax: RDF/XML, Turtle, Notation3, Triples, JSON-LD, RDF/JSON
- Basic idea is to state some knowledge, put that knowledge at a URI, then to process that knowledge automatically (semantic web) e.g. There is a person whose name is Simon
  - Subject: the resource we're referring to
  - Object: The value (resource or literal) associated with the subject
  - Predicate: a term that describes or modifies the subject, ie. denotes a relationship between subject & object



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YAML

- Originally "Yet Another Markup Language" but now "YAML Ain't Markup Language"
- Human readable language for data serialisation
- Often used for configuration files (.yaml files)
- https://yaml.org
- Specification (1.2): https://yaml.org/spec/1.2/spec.html

```
--- !clarkevans.com/^invoice
invoice: 34843
date   : 2001-01-23
bill-to: &id001
    given  : Chris
    family : Dumars
    address:
        lines: |
            458 Walkman Dr.
            Suite #292
        city    : Royal Oak
        state   : MI
        postal  : 48046
ship-to: *id001
product:
    - sku         : BL394D
      quantity    : 4
      description : Basketball
      price       : 450.00
    - sku         : BL4438H
      quantity    : 1
      description : Super Hoop
      price       : 2392.00
tax  : 251.42
total: 4443.52
comments: >
    Late afternoon is best.
    Backup contact is Nancy
    Billsmer @ 338-4338.
```

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ATOM & RSS

- XML languages used for "web feeds" & data syndication

- Share recent entries (blogging), site updates, full text, multimedia files with consumers (feed reader)

- Share with other sites (syndication) - pull feed of data and incorporate it into your site

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```
<?xml version="1.0" encoding="utf-8"?>

<feed xmlns="http://www.w3.org/2005/Atom">

	<title>Dr Simon Wells</title>
	<subtitle>sesquipedalia verba</subtitle>
	<link href="http://simonwells.org/feed/" rel="self" />
	<link href="http://simonwells.org/" />
	<id>urn:uuid:60a76c80-d399-11d9-b91C-0003939e0af6</id>
	<updated>2019-10-13T18:30:02Z</updated>


	<entry>
		<title>Publications</title>
		<link href="http://www.simonwells.org/publications/" />
		<link rel="alternate" type="text/html" href="http://www.simonwells.org/publications.html"/>
		<id>urn:uuid:1225c695-cfb8-4ebb-aaaa-80da344efa6a</id>
		<updated>2018-04-09T09:30:02Z</updated>
		<summary>Some text.</summary>
		<content type="xhtml">
			<div xmlns="http://www.w3.org/1999/xhtml">
				<p>S. Wells (2019) "A Paroxysm of Dissent: Partisan Political Advertising During the Brexit Campaign"
Abstract for paper presented at the 3rd European Conference on Argumentation: Reason to Dissent (ECA19), Groningen, Nethlands</
p>
			</div>
		</content>
		<author>
			<name>Simon Wells</name>
			<email>mail@simonwells.org</email>
		</author>
	</entry>

</feed>
```

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```
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<rss version="2.0" xmlns:atom="http://www.w3.org/2005/Atom">
  <channel>
    <title>Dr Simon Wells</title>
    <link>http://www.simonwells.org/</link>
    <description>Recent content on Dr Simon Wells</description>
    <generator>Hugo -- gohugo.io</generator>
    <language>en-gb</language>
    <copyright>Copyright &amp;amp;copy; 2001-2018 - Simon Wells</copyright>
    <lastBuildDate>Mon, 09 Apr 2018 00:00:00 +0000</lastBuildDate>

        <atom:link href="http://www.simonwells.org/index.xml" rel="self" type="application/rss+xml"/>

    <item>
      <title>Publications</title>
      <link>http://www.simonwells.org/publications/</link>
      <pubDate>Mon, 09 Apr 2018 00:00:00 +0000</pubDate>

      <guid>http://www.simonwells.org/publications/</guid>
      <description>S. Wells (2019) "A Paroxysm of Dissent: Partisan Political Advertising During the Brexit Campaign"
Abstract for paper presented at the 3rd European Conference on Argumentation: Reason to Dissent (ECA19),
Groningen, Nethlands</description>
    </item>

  </channel>
</rss>
```

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PUTTING IT ALL TOGETHER

Send an Event to Account route

PUT https://cool-web-app.example/accounts/<userid>

Example Request:

```
PUT /accounts/i-04cee0b5ed03c3-5c9b17c3 HTTP/1.1
Content-Type: application/json

{
    "auth": "XLQLrvxlc8IM6FGOv28aH5g0t35",
    "uid": "user@our.example",
    "contact": {"type": "mobile_number",
                "number": "00447982321123"}
}
```

- Interaction with a resource causes data manipulation.
- HTTP can return different types of data as a result of a request.
- HTTP can indicate the *type* of data being returned using the **mediatype** header.
- Data can be structured in various ways.
- But…

WHAT DO WE MEAN BY STORING DATA?

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SERVING PAGES

- Multiple options (with different advantages/disadvantages). Increasingly dynamic:
  - Static server + HTML in files (traditional static site).
  - Return HTML as string from Flask.
  - Return HTML as file from Flask (static serving).
  - Return HTML from template using Flask. Flask assembles & returns HTML by completing the template (dynamic page generation).
- Where is the data that is used to complete the template?

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TOWARDS DATA DRIVEN SITES

- Data can be *live* data, i.e. stored in variables in the Python app. Generated at runtime,
- Data can be retrieved from other locations, i.e. third-party APIs. Often JSON.
- Data can be retrieved from file on disk.
- Data can be retrieved from a database.
- When should we choose a database instead of disk storage?

```
from flask import Flask, g
import sqlite3

app = Flask(__name__)
db_location = 'var/test.db'

def get_db():
    db = getattr(g, 'db', None)
    if db is None:
        db = sqlite3.connect(db_location)
        g.db = db
    return db

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

def init_db():
    with app.app_context():
        db = get_db()
        with app.open_resource('schema.sql', mode='r') as f:
            db.cursor().executescript(f.read())
        db.commit()

@app.route("/")
def root():
    db = get_db()
    db.cursor().execute('insert into albums values
        (“American Beauty", "Grateful Dead", "CD")')
    db.commit()

    page = []
    page.append('<html><ul>')
    sql = "SELECT rowid, * FROM albums ORDER BY artist"
    for row in db.cursor().execute(sql):
        page.append('<li>')
        page.append(str(row))
        page.append('</li>')

    page.append('</ul></html>')
    return ''.join(page)
```

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SUMMARY

- This topic:
  - We've considered media-types, data transports, and data storage.
- Next:
  - API & Web Service Design & Development

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WRAPPING UP

- We've taken a look at:
- Data representation (JSON + others)
- Data transport (mediatypes)
- Data storage (SQLite)