UNIVERSITY OF Southampton

An automated framework to derive model variables from open transport data using R, PostgreSQL and OpenTripPlanner.

Marcus Young (m.a.young@soton.ac.uk)
PhD student, Transportation Research Group

31 March 2016

Outline

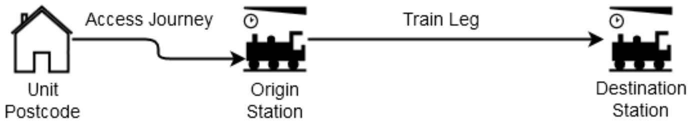
- Requirements of a multi-modal route planner
- OpenTripPlanner (OTP)
- GB open transport data
- Building the network in OTP
- Automated querying and processing
- Conclusions and further work

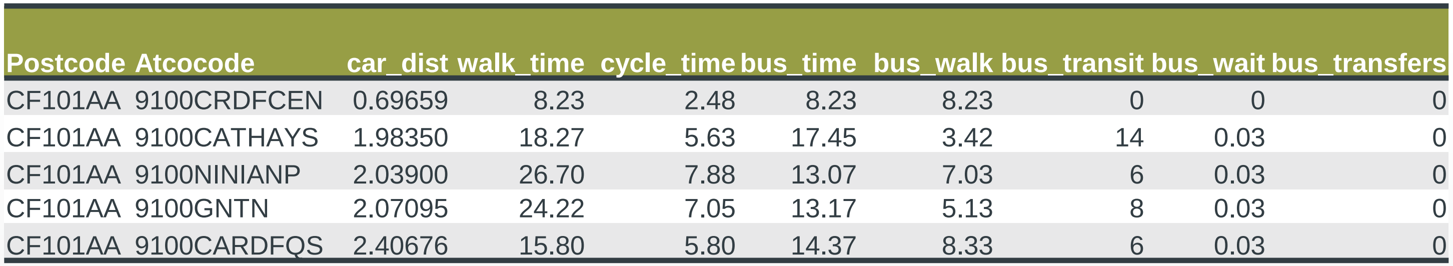
UNIVERSITY OF Southampton

Requirements of a multi-modal route planner

Requirements of a multi-modal route planner

- Generate variables for station choice models (up to 1M observations)



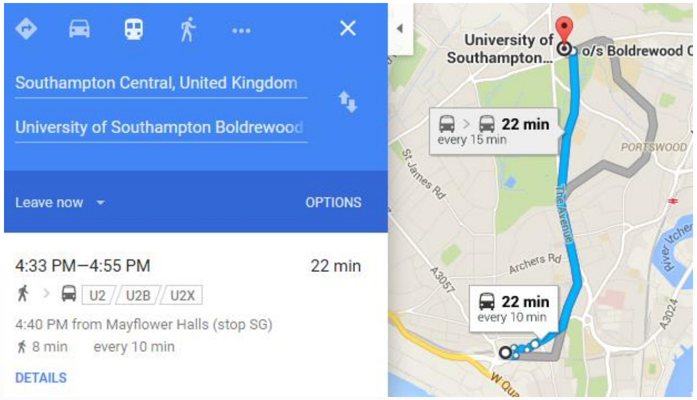


Postcode	Atcocode	car_dist	walk_time	cycle_time	bus_time	bus_walk	bus_transit	bus_wait	bus_transfers
CF101AA	9100CRDFCEN	0.69659	8.23	2.48	8.23	8.23	0	0	0
CF101AA	9100CATHAYS	1.98350	18.27	5.63	17.45	3.42	14	0.03	0
CF101AA	9100NINIANP	2.03900	26.70	7.88	13.07	7.03	6	0.03	0
CF101AA	9100GNTN	2.07095	24.22	7.05	13.17	5.13	8	0.03	0
CF101AA	9100CARDFQS	2.40676	15.80	5.80	14.37	8.33	6	0.03	0

- Compatible with UK open transport data
- Can use historic transit schedules
- Able to add proposed stations, routes and services

Existing options – expensive/limited

- RESTful API services:
  - Google Maps API (2000 free requests per day)
  - TransportAPI (1000 free requests per day)
  - TfL "Unified API" (free)
- Cannot use historic schedules or add proposed stops and services



Southampton Central, United Kingdom

University of Southampton Boldrewood

Leave now

OPTIONS

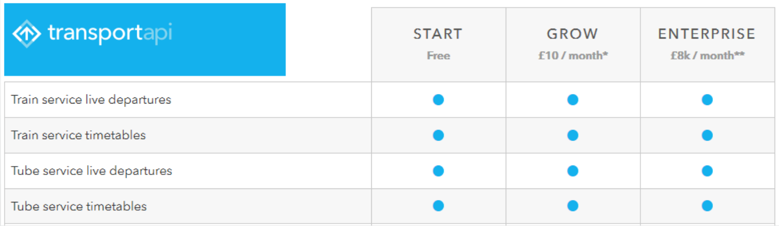
4:33 PM–4:55 PM 22 min

U2 / U2B / U2X

4:40 PM from Mayflower Halls (stop SG)

8 min every 10 min

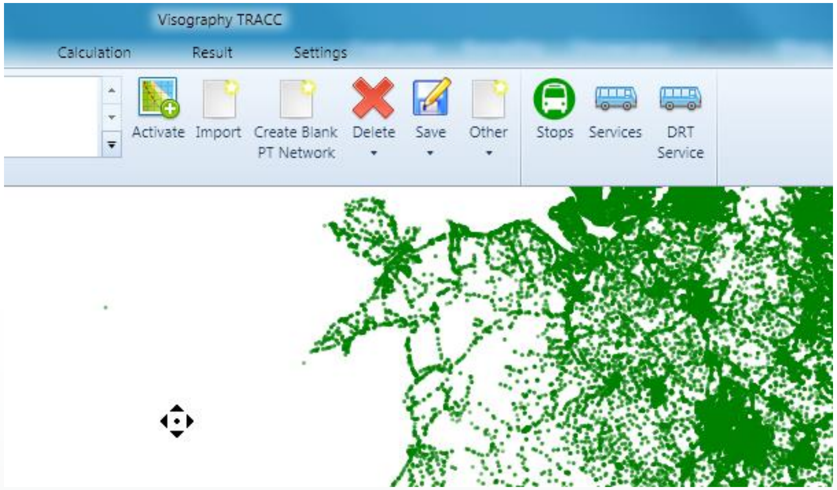
DETAILS



transportapi	START Free	GROW £10 / month*	ENTERPRISE £8k / month**
Train service live departures	●	●	●
Train service timetables	●	●	●
Tube service live departures	●	●	●
Tube service timetables	●	●	●

Existing options – expensive/limited

- Visography TRACC
  - Desktop Application
  - Expensive (£1000+)
  - Accessibility planning focus, restricted to analytical tools provided
  - Good support for UK open transport data



- Data is open, so an open source solution is preferable

UNIVERSITY OF Southampton

OpenTripPlanner

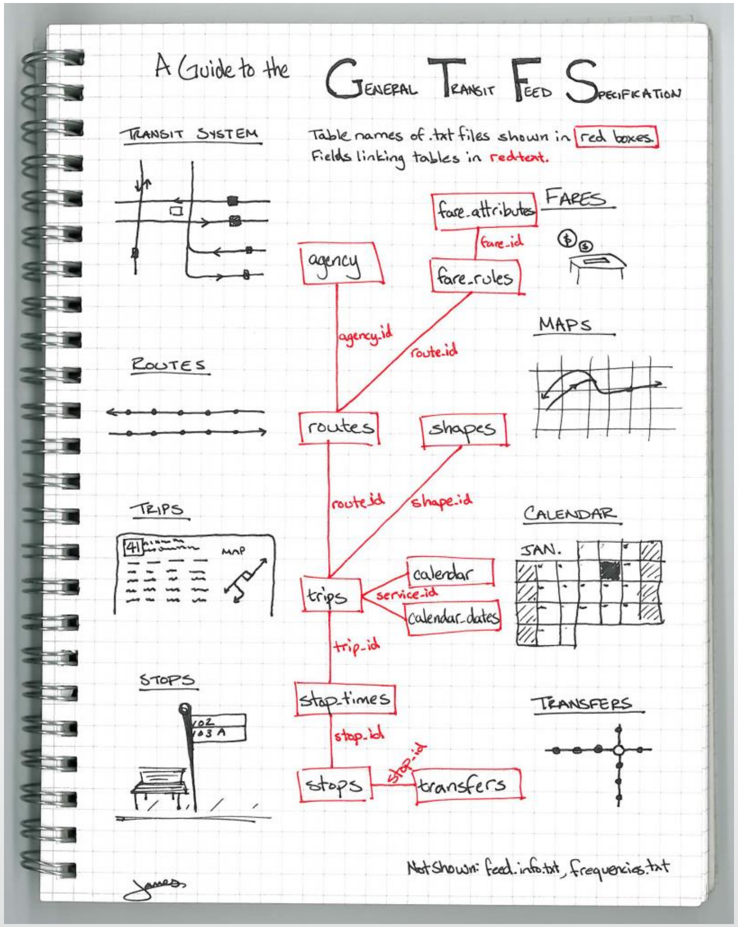
OpenTripPlanner

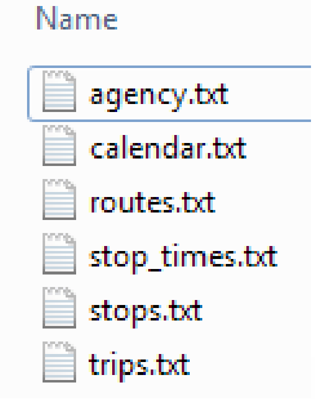
- Open-source, cross-platform, multi-modal planner written in JAVA
- Web front-end, sophisticated routing API
- Data requirements:
  - OpenStreetMap (OSM) - PBF or XML
  - GTFS feeds (multiple)
  - Digital elevation model (optional)

© OpenStreetMap contributors

OpenStreetMap powers map data on thousands of web sites, mobile apps, and hardware devices

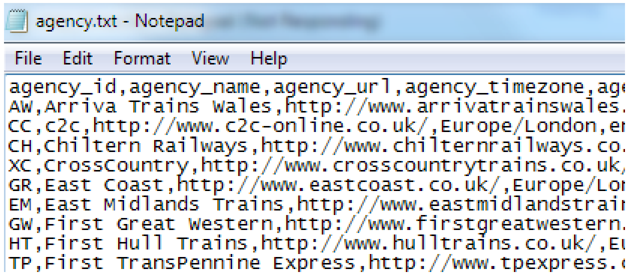
GTFS feed structure



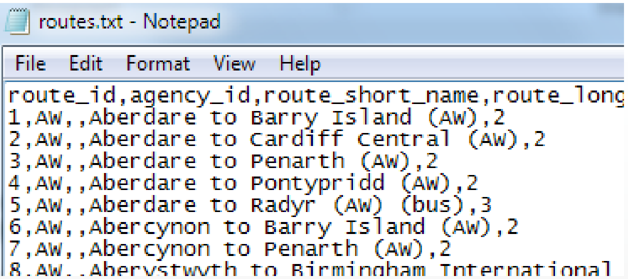


Name

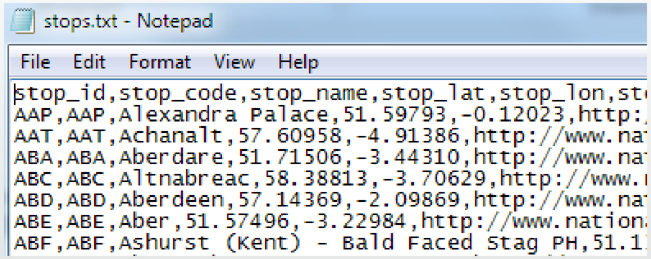
- agency.txt
- calendar.txt
- routes.txt
- stop_times.txt
- stops.txt
- trips.txt



```
agency_id,agency_name,agency_url,agency_timezone,age
AW,Arriva Trains Wales,http://www.arrivatrainswales.
CC,c2c,http://www.c2c-online.co.uk/,Europe/London,en
CH,Chiltern Railways,http://www.chilternrailways.co.
XC,CrossCountry,http://www.crosscountrytrains.co.uk,
GR,East Coast,http://www.eastcoast.co.uk/,Europe/Lon
EM,East Midlands Trains,http://www.eastmidlandstrain
GW,First Great Western,http://www.firstgreatwestern.
HT,First Hull Trains,http://www.hulltrains.co.uk/,Eu
TP,First TransPennine Express,http://www.tpexpress.
```



```
route_id,agency_id,route_short_name,route_long
1,AW,,Aberdare to Barry Island (AW),2
2,AW,,Aberdare to Cardiff Central (AW),2
3,AW,,Aberdare to Penarth (AW),2
4,AW,,Aberdare to Pontypridd (AW),2
5,AW,,Aberdare to Radyr (AW) (bus),3
6,AW,,Abercynon to Barry Island (AW),2
7,AW,,Abercynon to Penarth (AW),2
8,AW,,Aberystwyth to Birmingham International
```



```
stop_id,stop_code,stop_name,stop_lat,stop_lon,st
AAP,AAP,Alexandra Palace,51.59793,-0.12023,http:
AAT,AAT,Achanalt,57.60958,-4.91386,http://www.na
ABA,ABA,Aberdare,51.71506,-3.44310,http://www.na
ABC,ABC,Altnabreac,58.38813,-3.70629,http://www.
ABD,ABD,Aberdeen,57.14369,-2.09869,http://www.na
ABE,ABE,Aber,51.57496,-3.22984,http://www.nation
ABF,ABF,Ashurst (Kent) - Bald Faced Stag PH,51.1
```

http://blog.openplans.org/2012/08/the-openplans-guide-to-gtfs-data/

UNIVERSITY OF Southampton

GB open transport data

GB open transport data

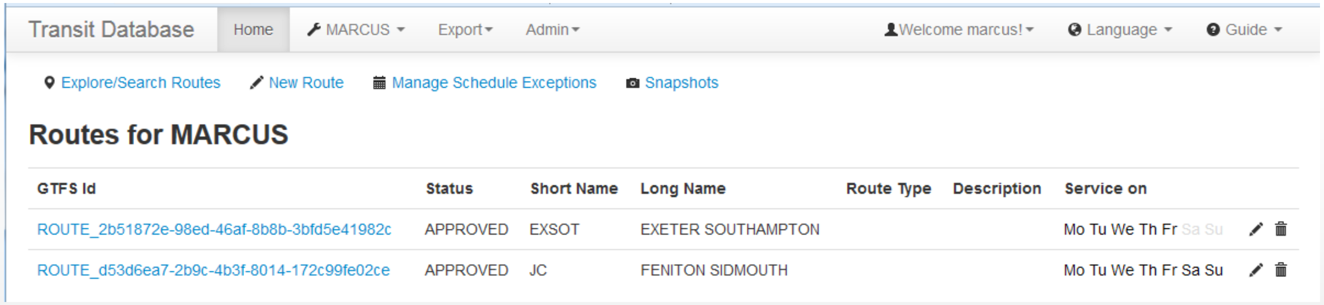
- Not provided as GTFS feeds
- GB train timetable data from ATOC
  - None standard CIF format
  - www.gbrail.com weekly GTFS version
- Bus, ferry, tram, light rail
  - Traveline National Dataset (not London)
  - TfL journey planner timetables
  - TransXchange (XML schema)

TransXChange to GTFS conversion

- TransXChange2GTFS Converter
  - Not maintained
  - Doesn’t work!
- Import to Visography TRACC and export as GTFS
  - Some post-processing required
  - Not ideal solution

Editing transit or street data

- Create a “proposed” GTFS feed
  - New stops, routes and services
  - Open source GTFS editor



Routes for MARCUS

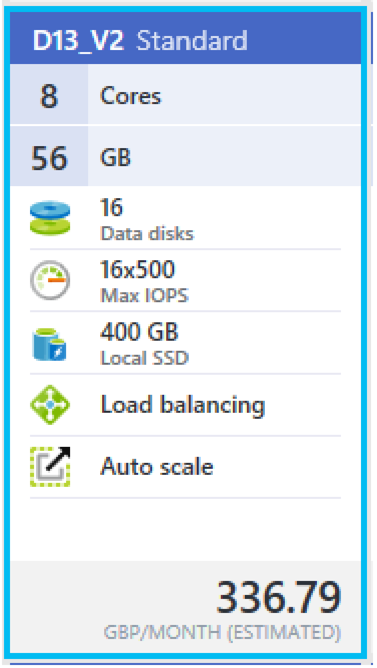
GTFS Id	Status	Short Name	Long Name	Route Type	Description	Service on
ROUTE_2b51872e-98ed-46af-8b8b-3bfd5e41982c	APPROVED	EXSOT	EXETER SOUTHAMPTON			Mo Tu We Th Fr Sa Su
ROUTE_d53d6ea7-2b9c-4b3f-8014-172c99fe02ce	APPROVED	JC	FENITON SIDMOUTH			Mo Tu We Th Fr Sa Su

- Edit OpenStreetMap data (e.g. using JOSM)
  - Add new streets
  - Place restrictions on streets

Building the graph (network)

Building the graph

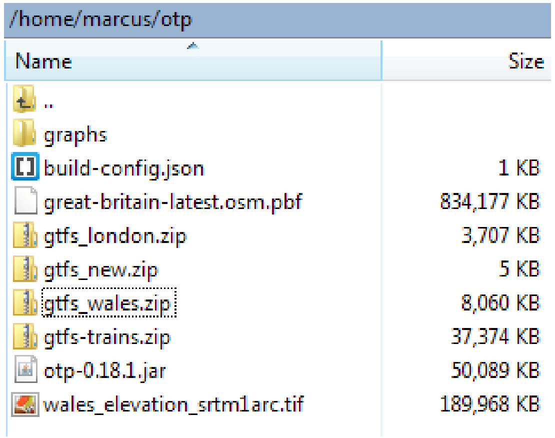
- High RAM requirement
- Use virtual machine (VM) on Microsoft Azure cloud platform



D13_V2 Standard

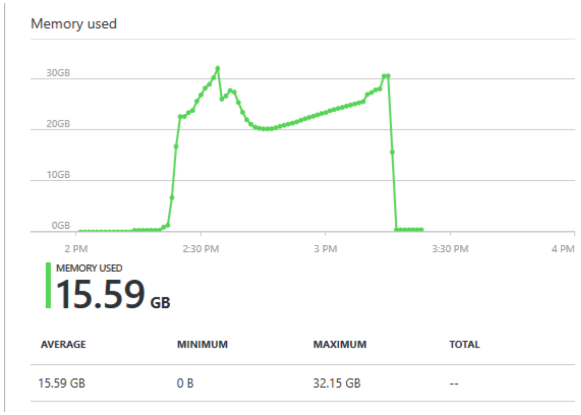
8	Cores
56	GB
	16 Data disks
	16x500 Max IOPS
	400 GB Local SSD
	Load balancing
	Auto scale

336.79
GBP/MONTH (ESTIMATED)



/home/marcus/otp

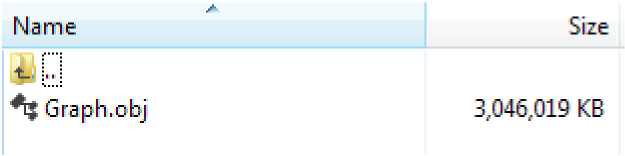
Name	Size
..	
graphs	
build-config.json	1 KB
great-britain-latest.osm.pbf	834,177 KB
gtfs_london.zip	3,707 KB
gtfs_new.zip	5 KB
gtfs_wales.zip	8,060 KB
gtfs-trains.zip	37,374 KB
otp-0.18.1.jar	50,089 KB
wales_elevation_srtm1arc.tif	189,968 KB



MEMORY USED
15.59 GB

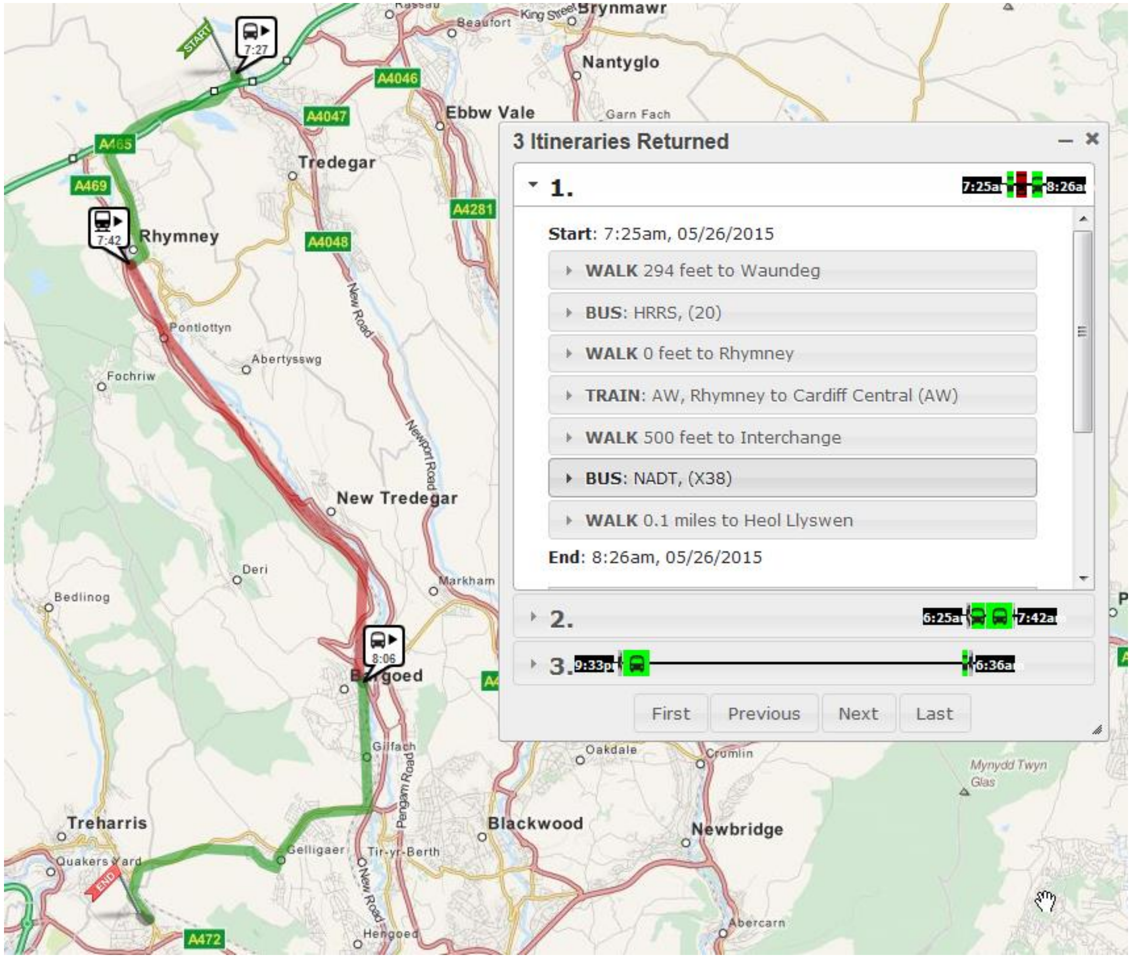
AVERAGE	MINIMUM	MAXIMUM	TOTAL
15.59 GB	0 B	32.15 GB	--

```
Java -Xmx56G -jar otp-0.18.1.jar --build /home/Marcus/otp
```



Name	Size
..	
Graph.obj	3,046,019 KB

OTP web interface



3 Itineraries Returned

1. 7:25a 8:26a

Start: 7:25am, 05/26/2015

- **WALK** 294 feet to Waundeg
- **BUS**: HRRS, (20)
- **WALK** 0 feet to Rhymney
- **TRAIN**: AW, Rhymney to Cardiff Central (AW)
- **WALK** 500 feet to Interchange
- **BUS**: NADT, (X38)
- **WALK** 0.1 miles to Heol Llyswen

End: 8:26am, 05/26/2015

2. 6:25a 7:42a

3. 9:33p 6:36a

UNIVERSITY OF Southampton

Automated querying & processing

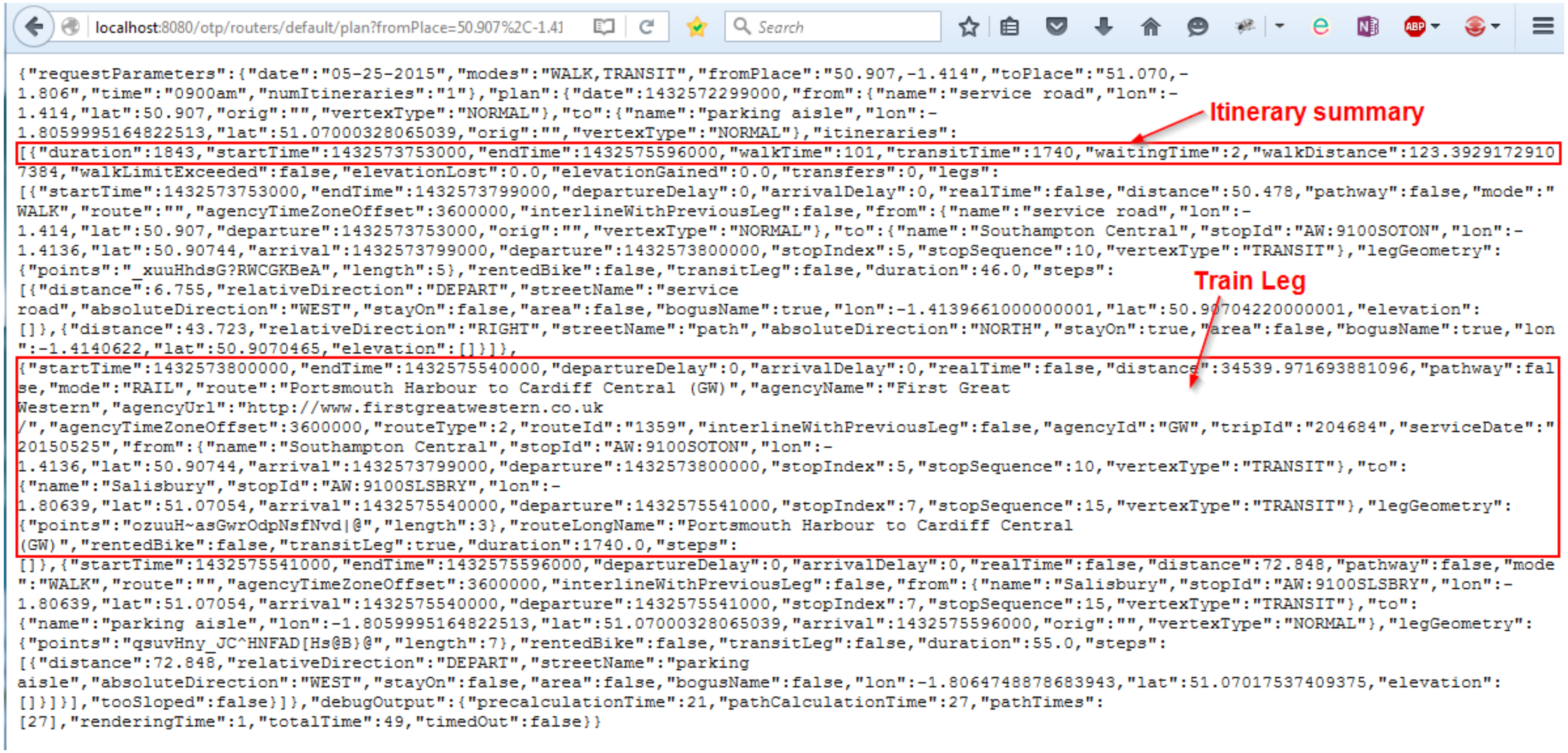
Querying OTP – the routing API

API Parameter (examples)	Description
fromPlace	The start location -- either latitude, longitude pair in degrees or a Vertex label. For example, 40.714476,-74.005966 or mtanyctsubway_A27_S.
toPlace	The end location (see fromPlace for format).
date	The date that the trip should depart (or arrive, for requests where arriveBy is true).
time	The time that the trip should depart (or arrive, for requests where arriveBy is true).
maxWalkDistance	The maximum distance (in meters) the user is willing to walk. Defaults to unlimited.
walkReluctance	A multiplier for how bad walking is, compared to being in transit for equal lengths of time. Defaults to 2.
modes	The set of modes that a user is willing to use, with qualifiers stating whether vehicles should be parked, rented, etc.
minTransferTime	The minimum time, in seconds, between successive trips on different vehicles.
transferPenalty	An additional penalty added to boardings after the first.
maxTransfers	The maximum number of transfers (that is, one plus the maximum number of boardings) that a trip will be allowed.

http://localhost:8080/otp/routers/default/plan?**fromPlace=50.907%2C-1.414**&**toPlace=51.070%2C-1.806**&**modes=WALK,TRANSIT**&**time=0900am**&**date=05-25-2015**

Querying OTP – JSON response

http://localhost:8080/otp/routers/default/plan?fromPlace=50.907%2C-1.414&toPlace=51.070%2C-1.806&modes=WALK,TRANSIT&time=0900am&date=05-25-2015


localhost:8080/otp/routers/default/plan?fromPlace=50.907%2C-1.41
Search

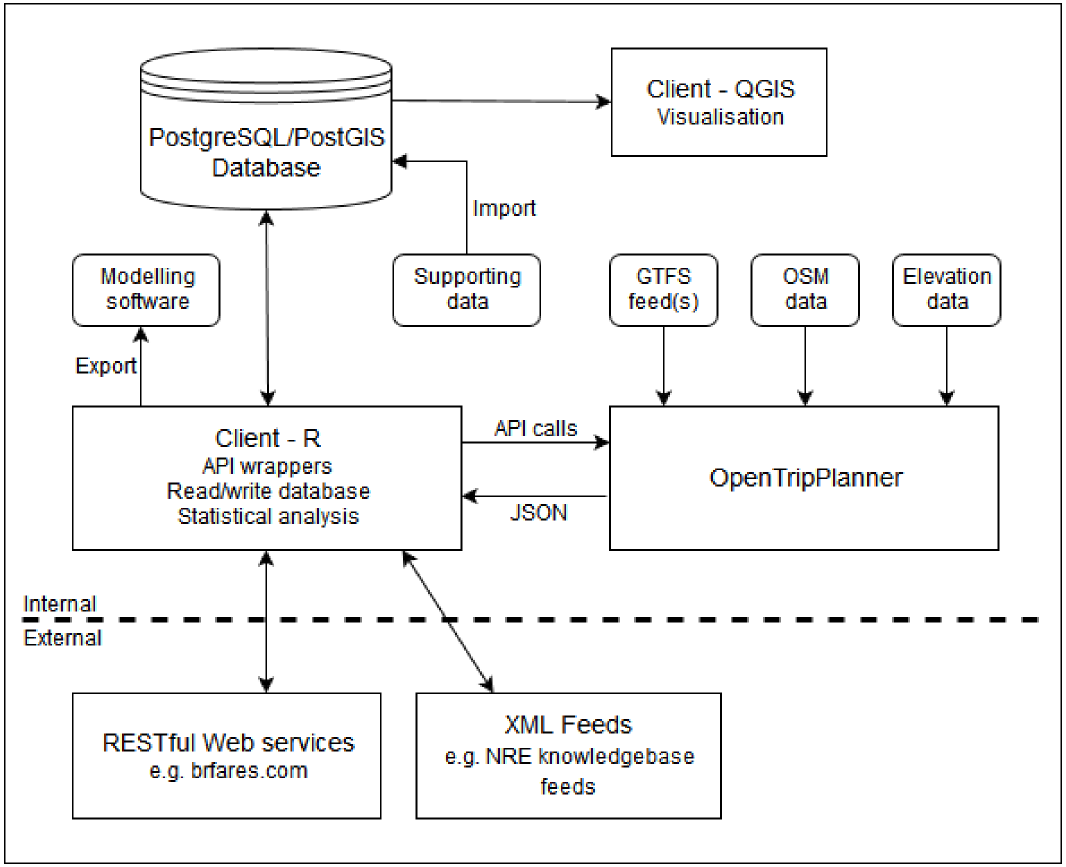
```
{"requestParameters":{"date":"05-25-2015","modes":"WALK,TRANSIT","fromPlace":"50.907,-1.414","toPlace":"51.070,-
1.806","time":"0900am","numItineraries":"1"},"plan":{"date":1432572299000,"from":{"name":"service road","lon":-
1.414,"lat":50.907,"orig":"","vertexType":"NORMAL"},"to":{"name":"parking aisle","lon":-
1.8059995164822513,"lat":51.07000328065039,"orig":"","vertexType":"NORMAL"},"itineraries":
[{"duration":1843,"startTime":1432573753000,"endTime":1432575596000,"walkTime":101,"transitTime":1740,"waitingTime":2,"walkDistance":123.3929172910
7384,"walkLimitExceeded":false,"elevationLost":0.0,"elevationGained":0.0,"transfers":0,"legs":
[{"startTime":1432573753000,"endTime":1432573799000,"departureDelay":0,"arrivalDelay":0,"realTime":false,"distance":50.478,"pathway":false,"mode":"
WALK","route":"","agencyTimeZoneOffset":3600000,"interlineWithPreviousLeg":false,"from":{"name":"service road","lon":-
1.414,"lat":50.907,"departure":1432573753000,"orig":"","vertexType":"NORMAL"},"to":{"name":"Southampton Central","stopId":"AW:9100SOTON","lon":-
1.4136,"lat":50.90744,"arrival":1432573799000,"departure":1432573800000,"stopIndex":5,"stopSequence":10,"vertexType":"TRANSIT"},"legGeometry":
{"points":"_xuuHhdsG?RWCGKBeA","length":5},"rentedBike":false,"transitLeg":false,"duration":46.0,"steps":
[{"distance":6.755,"relativeDirection":"DEPART","streetName":"service
road","absoluteDirection":"WEST","stayOn":false,"area":false,"bogusName":true,"lon":-1.4139661000000001,"lat":50.9070422000001,"elevation":
[]},{"distance":43.723,"relativeDirection":"RIGHT","streetName":"path","absoluteDirection":"NORTH","stayOn":true,"area":false,"bogusName":true,"lon
":-1.4140622,"lat":50.9070465,"elevation":[]}]},
{"startTime":1432573800000,"endTime":1432575540000,"departureDelay":0,"arrivalDelay":0,"realTime":false,"distance":34539.971693881096,"pathway":fal
se,"mode":"RAIL","route":"Portsmouth Harbour to Cardiff Central (GW)","agencyName":"First Great
Western","agencyUrl":"http://www.firstgreatwestern.co.uk
/","agencyTimeZoneOffset":3600000,"routeType":2,"routeId":"1359","interlineWithPreviousLeg":false,"agencyId":"GW","tripId":"204684","serviceDate":"
20150525","from":{"name":"Southampton Central","stopId":"AW:9100SOTON","lon":-
1.4136,"lat":50.90744,"arrival":1432573799000,"departure":1432573800000,"stopIndex":5,"stopSequence":10,"vertexType":"TRANSIT"},"to":
{"name":"Salisbury","stopId":"AW:9100SLSBRY","lon":-
1.80639,"lat":51.07054,"arrival":1432575540000,"departure":1432575541000,"stopIndex":7,"stopSequence":15,"vertexType":"TRANSIT"},"legGeometry":
{"points":"ozuuH~asGwrOdpNsfNvd|@","length":3},"routeLongName":"Portsmouth Harbour to Cardiff Central
(GW)","rentedBike":false,"transitLeg":true,"duration":1740.0,"steps":
[]},{"startTime":1432575541000,"endTime":1432575596000,"departureDelay":0,"arrivalDelay":0,"realTime":false,"distance":72.848,"pathway":false,"mode
":"WALK","route":"","agencyTimeZoneOffset":3600000,"interlineWithPreviousLeg":false,"from":{"name":"Salisbury","stopId":"AW:9100SLSBRY","lon":-
1.80639,"lat":51.07054,"arrival":1432575540000,"departure":1432575541000,"stopIndex":7,"stopSequence":15,"vertexType":"TRANSIT"},"to":
{"name":"parking aisle","lon":-1.8059995164822513,"lat":51.07000328065039,"arrival":1432575596000,"orig":"","vertexType":"NORMAL"},"legGeometry":
{"points":"qsuvHny_JC^HNFAD[Hs@B}@","length":7},"rentedBike":false,"transitLeg":false,"duration":55.0,"steps":
[{"distance":72.848,"relativeDirection":"DEPART","streetName":"parking
aisle","absoluteDirection":"WEST","stayOn":false,"area":false,"bogusName":false,"lon":-1.8064748878683943,"lat":51.07017537409375,"elevation":
[]}]}],"tooSloped":false}]},"debugOutput":{"precalculationTime":21,"pathCalculationTime":27,"pathTimes":
[27],"renderingTime":1,"totalTime":49,"timedOut":false}}
```

Itinerary summary

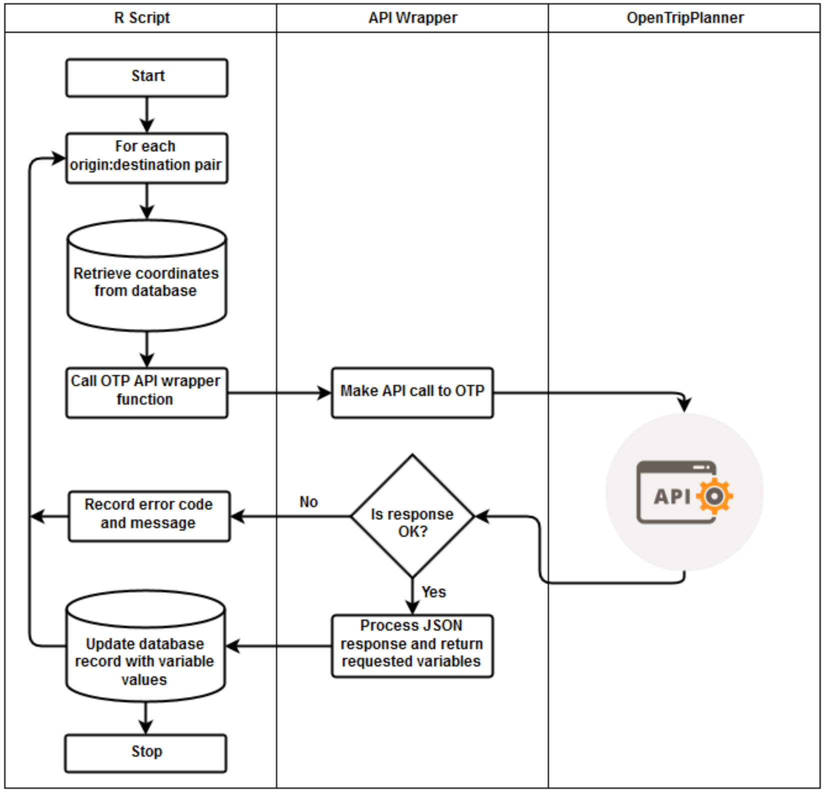
Train Leg

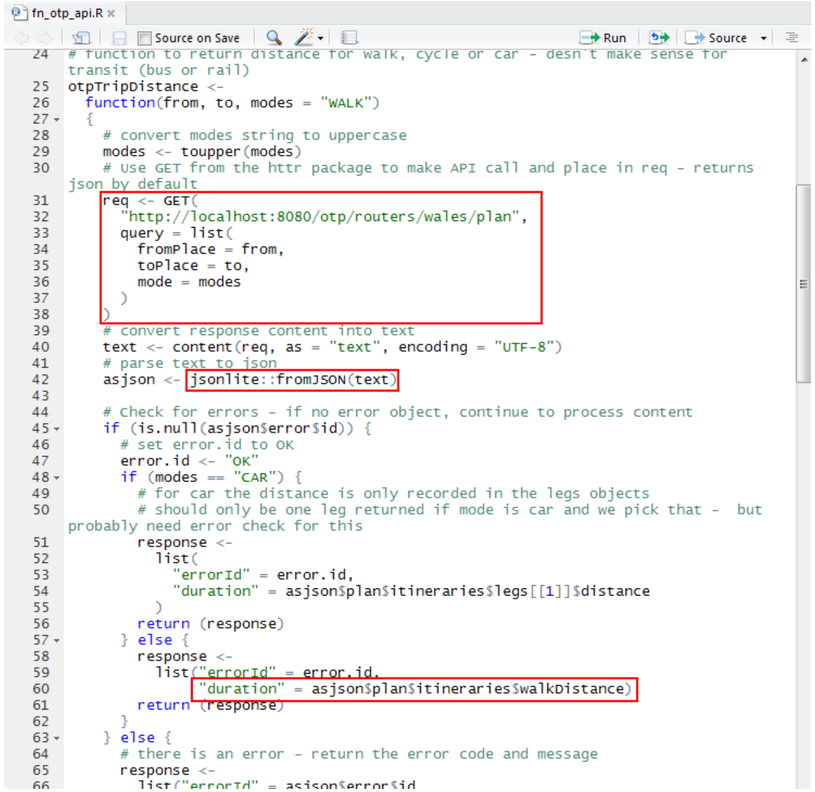
UNIVERSITY OF Southampton

Framework for automating the process



Automated querying & processing using R


R Script
API Wrapper
OpenTripPlanner
Start
For each origin:destination pair
Retrieve coordinates from database
Call OTP API wrapper function
Make API call to OTP
API
Record error code and message
No
Is response OK?
Yes
Process JSON response and return requested variables
Update database record with variable values
Stop

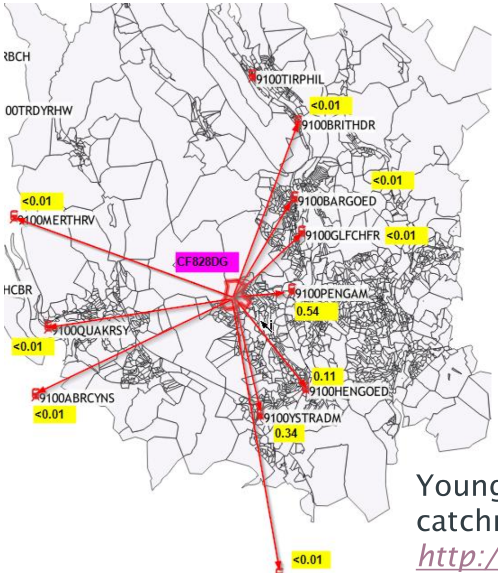


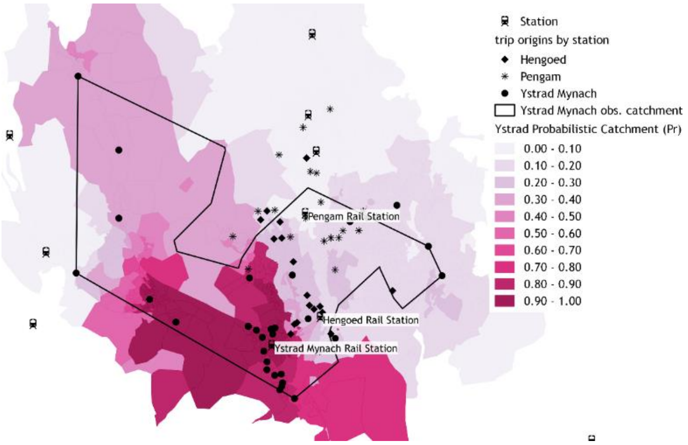
```r
# function to return distance for walk, cycle or car - desn't make sense for transit (bus or rail)
otpTripDistance <-
  function(from, to, modes = "WALK")
  {
    # convert modes string to uppercase
    modes <- toupper(modes)
    # Use GET from the httr package to make API call and place in req - returns json by default
    req <- GET(
      "http://localhost:8080/otp/routers/wales/plan",
      query = list(
        fromPlace = from,
        toPlace = to,
        mode = modes
      )
    )
    # convert response content into text
    text <- content(req, as = "text", encoding = "UTF-8")
    # parse text to json
    asjson <- jsonlite::fromJSON(text)

    # Check for errors - if no error object, continue to process content
    if (is.null(asjson$error$id)) {
      # set error.id to OK
      error.id <- "OK"
      if (modes == "CAR") {
        # for car the distance is only recorded in the legs objects
        # should only be one leg returned if mode is car and we pick that -  but probably need error check for this
        response <-
          list(
            "errorId" = error.id,
            "duration" = asjson$plan$itineraries$legs[[1]]$distance
          )
        return (response)
      } else {
        response <-
          list("errorId" = error.id,
               "duration" = asjson$plan$itineraries$walkDistance)
        return (response)
      }
    } else {
      # there is an error - return the error code and message
      response <-
        list("errorId" = asjson$error$id
```

Case study application of framework

- Generated variables for a station choice model with some 50,000 observations.

- Generated variables for up 122,000 unit postcodes to produce probabilistic station catchments.





Young, Marcus and Blainey, Simon (2016) Defining probability-based rail station catchments for demand modelling. In, *48th Annual UTSG Conference, 06 - 08 Jan 2016.* *http://eprints.soton.ac.uk/384539/*

UNIVERSITY OF Southampton

Conclusions and further work

UNIVERSITY OF Southampton

Conclusions and further work

- Created a multi-modal route planner for GB and a framework to automate querying, processing and storage - using open source tools and open data
- Main limitation:
  - Using TRACC to convert Traveline/TfL data to GTFS
- Future plans:
  - Larger survey datasets – generating variables for up to 1M observations.
  - Contribute an OTP API wrapper R Package