

Uber Movement: Travel Times Calculation Methodology

Uber Movement's Travel Times solution provides cities average travel time calculations between two 'zones' in a region for a given time and date. Zones defined for a region are commonly census tracts, traffic analysis zones (TAZ), or neighborhoods.

This document describes how zone-to-zone travel times are synthesized from GPS trace pings from cars on Uber's network, and the steps taken to ensure we're preserving rider-driver privacy throughout the Movement tool.

Since all Uber driver-partners use a smartphone to handle the logistics of their trips, anonymized and aggregated travel data can be used to measure a region's transportation infrastructure. This approach is particularly well-adapted to deliver accurate data where it is most scarce: smaller roads and arterials with limited commercial traffic and where fixed sensor infrastructure is a costly and inefficient investment.

The Uber Partner app, while on trip, records latitude, longitude, and a timestamp (Date/time) every 4 seconds. These GPS trace pings are commonly used to provide navigational routing, fare calculations, match partners with riders, and user experience elements, such as plotting the position of the car in the Uber Rider app. When aggregated, these GPS trace pings can also be used to derive average travel times between the zones in a given region. Data precision is aided by the large number of GPS trace pings Uber is able to aggregate for a given stretch of road, thereby providing reliable estimates.

Uber Movement processes these GPS trace pings using the following high-level steps:

STEP 1: For each trip, unsorted GPS trace pings are geocoded into an appropriate zone as defined by a shapefile.

STEP 2: GPS trace pings are grouped by travel zone and ordered by timestamp (Date/time).

STEP 3: For each zone a trip passes through, the mean GPS ping is selected.

STEP 4: The elapsed time from each mean GPS ping to all subsequent GPS pings is measured, thereby providing zone-to-zone travel times from a given trip.

STEP 5: Zone-to-zone travel times are aggregated from all trips to an hourly level.

STEP 6: Travel time averages are removed for zones that either a) do not meet a minimum number of trips or b) the minimum diversity of riders and drivers necessary to preserve rider-driver privacy.

STEP 7: Zone-to-zone travel time averages are made available via Movement's interactive travel times solution, including several available CSV export options.

Travel Times Processing in Detail

The following provides a more detailed walkthrough of the steps above. A simplified extract of unprocessed GPS trace ping data appears as the following:

```
(Trip1, Latitude1, Longitude1, Date/time1)
(Trip1, Latitude2, Longitude2, Date/time2)
(Trip1, Latitude4, Longitude4, Date/time3)
(Trip1, Latitude3, Longitude3, Date/time4)
...
(Trip2, Latitude1, Longitude1, Date/time1)
(Trip2, Latitude2, Longitude2, Date/time2)
(Trip3, Latitude3, Longitude3, Date/time3))
...
```

1. Geocoding: At this step we geocode every GPS trace ping to a travel zone (ie, census tracts). Ping data is matched to the zone which the ping falls within and appended to the dataset as below:

```
(Trip1, Latitude1, Longitude1, Date/time1, Zone1)
(Trip1, Latitude2, Longitude2, Date/time2, Zone1)
(Trip1, Latitude4, Longitude4, Date/time4, Zone2)
(Trip1, Latitude3, Longitude3, Date/time3, Zone1)
(Trip1, Latitude5, Longitude5, Date/time5, Zone2)
(Trip1, Latitude6, Longitude6, Date/time6, Zone2)
(Trip1, Latitude7, Longitude7, Date/time7, Zone3)
(Trip1, Latitude8, Longitude8, Date/time8, Zone3)
(Trip1, Latitude9, Longitude9, Date/time9, Zone3)
...
(Trip2, Latitude1, Longitude1, Date/time1, Zone12)
(Trip2, Latitude2, Longitude2, Date/time2, Zone12)
(Trip2, Latitude3, Longitude3, Date/time3, Zone13)
...
```

2. Grouping and Ordering by Zones: At this step we order GPS trace pings by time and group into consecutive pings belonging to same group

```
-----
(Trip1, Latitude1, Longitude1, Date/time1, Zone1)
(Trip1, Latitude2, Longitude2, Date/time2, Zone1)
(Trip1, Latitude3, Longitude3, Date/time3, Zone1)
-----
(Trip1, Latitude4, Longitude4, Date/time4, Zone2)
(Trip1, Latitude5, Longitude5, Date/time5, Zone2)
```

```

(Trip1, Latitude6, Longitude6, Date/time6, Zone2)
-----
(Trip1, Latitude7, Longitude7, Date/time7, Zone3)
(Trip1, Latitude8, Longitude8, Date/time8, Zone3)
(Trip1, Latitude9, Longitude9, Date/time9, Zone3)
-----
..
-----
(Trip2, Latitude1, Longitude1, Date/time1, Zone12)
(Trip2, Latitude2, Longitude2, Date/time2, Zone12)
-----
(Trip2, Latitude3, Longitude3, Date/time3, Zone13)
-----
..

```

3. Find Zone Mean Points: Let's consider just Trip1. The mean GPS trace ping has been highlighted:

```

-----
(Trip1, Latitude1, Longitude1, Date/time1, Zone1)
(Trip1, Latitude2, Longitude2, Date/time2, Zone1)
(Trip1, Latitude3, Longitude3, Date/time3, Zone1)
-----
(Trip1, Latitude4, Longitude4, Date/time4, Zone2)
(Trip1, Latitude5, Longitude5, Date/time5, Zone2)
(Trip1, Latitude6, Longitude6, Date/time6, Zone2)
-----
(Trip1, Latitude7, Longitude7, Date/time7, Zone3)
(Trip1, Latitude8, Longitude8, Date/time8, Zone3)
(Trip1, Latitude9, Longitude9, Date/time9, Zone3)
-----

```

From this step onwards, we only consider one single GPS ping per zone a trip have zone through. At the end of this step the data flowing out would look like:

```

-----
(Trip1, Latitude1, Longitude1, Date/time1, Zone1)
(Trip1, Latitude5, Longitude5, Date/time5, Zone2)
(Trip1, Latitude8, Longitude8, Date/time8, Zone3)
-----
(Trip2, Latitude4, Longitude4, Date/time4, Zone21)
(Trip2, Latitude6, Longitude6, Date/time6, Zone22)
(Trip2, Latitude9, Longitude9, Date/time9, Zone23)
-----
..

```

4. Trip-Level Travel Time Calculations: At this step, we calculate how long a trip in question took to travel from one zone to the other it navigated through. Let's consider an example trip.

```

-----
(Trip6, Latitude01, Longitude01, Date/time01, Zone1)
(Trip6, Latitude05, Longitude05, Date/time05, Zone2)
(Trip6, Latitude08, Longitude08, Date/time08, Zone3)

```

(Trip6, Latitude14, Longitude14, Date/time14, Zone21)

The example trip 'Trip6' here has gone through (Zone1, Zone2, Zone3, Zone21). At this step we calculate the time Trip6 took to travel through zones, as below:

<u>TripId</u>	<u>SourceZone</u>	<u>DstZone</u>	<u>Time</u>	<u>StartDate/time</u>
Trip6	Zone1	Zone2	(Date/time05 - Date/time01) = Time1	Date/time01
Trip6	Zone1	Zone3	(Date/time08 - Date/time01) = Time2	Date/time01
Trip6	Zone1	Zone21	(Date/time14 - Date/time01) = Time3	Date/time01
Trip6	Zone2	Zone3	(Date/time08 - Date/time05) = Time4	Date/time05
Trip6	Zone2	Zone21	(Date/time14 - Date/time05) = Time5	Date/time05
Trip6	Zone3	Zone21	(Date/time14 - Date/time08) = Time6	Date/time08

The output of the step would look like:

(Trip6, Zone1, Zone3, Time1, StartDate/time1)
(Trip6, Zone2, Zone3, Time2, StartDate/time2)
(Trip6, Zone3, Zone4, Time3, StartDate/time3)
(Trip6, Zone1, Zone4, Time4, StartDate/time4)

(Trip7, Zone1, Zone3, Time11, StartDate/time11)
(Trip7, Zone2, Zone3, Time12, StartDate/time12)
(Trip7, Zone3, Zone4, Time13, StartDate/time13)
(Trip7, Zone1, Zone5, Time14, StartDate/time14)

5. Building Hourly Aggregates: We now bin the travel times into hourly buckets (24 buckets for a given day) and within each bucket aggregate these measurements into a zone-to-zone travel time. Subsequently, when selecting a time range in Uber Movement's user interface, the appropriate buckets are selected to calculate mean and range.

(startDate/timeHourBoundary1, Trip6, Zone1, Zone3, Time1, startDate/time1)
(startDate/timeHourBoundary1, Trip6, Zone2, Zone3, Time2, startDate/time2)
(startDate/timeHourBoundary2, Trip6, Zone3, Zone4, Time3, startDate/time3)
(startDate/timeHourBoundary2, Trip6, Zone1, Zone4, Time4, startDate/time4)

(startDate/timeHourBoundary1, Trip7, Zone1, Zone3, Time11, startDate/time11)
(startDate/timeHourBoundary3, Trip7, Zone2, Zone3, Time12, startDate/time12)
(startDate/timeHourBoundary2, Trip7, Zone3, Zone4, Time13, startDate/time13)
(startDate/timeHourBoundary4, Trip7, Zone1, Zone5, Time14, startDate/time14)

6. Data added to Uber Movement: The calculated travel time averages are made available through a web-based interactive visualization, including CSV export options. The resulting data available via Movement includes:
- Date range
 - Display Name for Zone
 - Origin and Destination zone geometry
 - Average Travel Time
 - Average Range - Lower Bound (seconds)
 - Average Range - Upper Bound (seconds)