A LaTeX TEMPLATE FOR PAPERS SUBMITTED TO THE TRANSPORTATION RESEARCH BOARD

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ABSTRACT

For the last decades, social and economic needs increased swiftly in this urban world. To help this growth, new urban structures must emerge which complexifies societies. Public transportation illustrates this case: more and more bus or subway stations appearing, creating dependency between them. The situation raised interest among the research community that tries to find a solution to visualize and quantify this complexity. This paper provides ways to compute accessibility for the Île-de-France region in a general way. Meaning that the accessibility value for each point will be computed regarding a certain amounts of different points in the network (more details in the next section) . Parallelism, sampling, scaling will be tackled.

Keywords: Transportation, Accessibility

INTRODUCTION

Public transportation became part of our everyday life and totally changed the way people manage their time and tasks. Their structure is well known and can be visualized like a network where the stations are the nodes and the connexions between them are the links. It helps representing public transportations, but they remain complex and interdependent. Being able to quantify this complexity and to understand them could help making them more efficient and reliable which may lead to increasing our quality of life. In a Big Data era, data are overflowing, more precisely data about public transportation. Google encourages transit operators to use the GTFS standard file so data can be used in a uniform way. More and more companies released their data which can be accessed easily. They will be used to compute and evaluate the accessibility of every nodes of our network. In general, the accessibility assesses the facility of accessing certain places in a region. Having a great accessibility means that the place is well-serviced. In our case, the accessibility can be defined as the average best time to reach a node, from all the other nodes of the network. Using this value, we can visualize the results with an isochrone map for a given day and time. In this paper, our network will be composed of stop points (from buses, subways, trains etc.), provided by the RATP (?). We also aim to evaluate the minimum number of nodes need to take into account to have an accessibility that converges.

RELATED WORK

(*1*) has been published in 2016. In this article, the authors provide a novel user-based representation of public transportation systems, which combines representations, accounting for the presence of multiple lines while considering the total travel time, its variability across the schedule, and taking into account the number of transfers necessary. In their networks, stations are identified as nodes, and links are the transportation connections between them. They also used open shared GTFS data to carry out their analysis of French municipalities.

They compute the average time to go from a stop i to a stop j with the PT line lk as the sum of the average waiting time (based on the frequency of line lk) and the average time spent on the vehicle. Then, they calculate the shortest time paths between origin and destination as the smallest durations measured (the sum of the average time needed to wait, travel and transfer between lines) among the different alternative paths (PT lines). The shortest path between any pair of stops are given by an adapted version of Dijkstra's algorithm. They focus their analysis between 7 am and 10 am during 4 weeks. In (*2*), they use a probabilistic definition of the accessibility of a node i (random walk) and the software Merkaartor which supplies information about both the positions of streets and underground routes. They extend their work to Paris and London. This paper does not consider the time in its accessibility measure. In (*3*), they focus on Shanghai and classify accessibilty into five levels from very high to very low according to the traveling time (30, 45, 60, 75 min). Travel times are computed within ArcGIS software. They use the same methodology as OTP does: walking time (velocity values from 1.14m/s to 1.51m/s), waiting time, transportation time, eventually transfer time. MaxWalkDistance = 600m (it is difficult for passengers with carry-on luggage to walk longer)

ACCESSIBILITY MEASURE

We partition the surface of Île de France in square cells with edge eKm (in our experiments we use $e = 2$Km). Each node is the center of a cell. We take the information about the cells from EURO-

STAT.[1] We only consider cells whose population density is more than 100 individuals per Km2. We denote with $\mathscr{I}$ the set of such cells. We define the accessibility measure of each node $i \in \mathscr{I}$ as the mean of the shortest times to reach every other nodes of the network. Hence, the greatest the accessibility measure of a stop point is the less, the stop point is accessible. The accessibility of a point i is defined as followed (*4*):

$$A(i) = \sum_{k=1}^{p} \frac{t_{i,a_k}}{p}, i \in \mathscr{I}$$

With :

- p : size of the random subset;
- $(a_k)_{k=1}^{p}$: set of p random nodes extracted from $\mathscr{I}$.
- $t_{k,l}$: shortest time to go from point k to point l

To compute each t_{i,a_j}, we perform a query to OpenTripPlanner, using the GPS coordinates of i and a_j. Note that, to compute the accessibility of point i, we need to perform p queries.

The query for a chosen time of a chosen day is as follows :

```
http://localhost:8080/otp/routers/default/plan?fromPlace=coordA&toPlace=coordB
&date=DATE&time=TIME&maxWalkDistance=2500&numItineraries=1

- maxWalkDistance is the maximum distance (in meters) the user is willing to walk.
- numItineraries is the maximum number of possible itineraries to return.
```

[1] https://ec.europa.eu/eurostat/web/gisco/geodata/reference-data/grids

The query returns a JSON containing $t_{k,l}$, the shortest time to go from point k to point l :


```
{
  "requestParameters" : {
    [...]
    "itineraries" : [ {
      "duration" : shortestTime,
      "startTime" : XXX,
      "endTime" : XXX,
      "walkTime" : XXX,
        [...]
    }]
    [...]
}
```


We have randomly picked 1000 data points among the stop point data provided by the RATP (more than 60000 stop points). To reduce the computation time, we have decided to compute the accessibility measure of each point not with the entire network (1000 stop points) but with a random subset of p =200 stop points. We also divide the calculations into N sub-process. The division happens as followed : the k-th process will only compute the accessibility of points i such that :

$$i\%N = k$$

For a graphical representation :

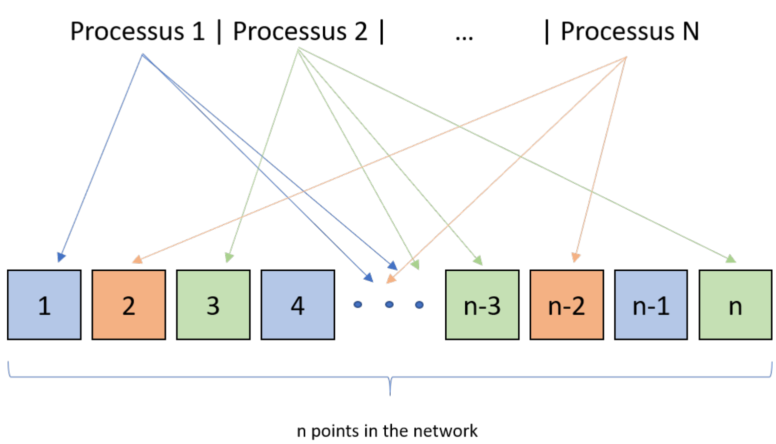

FIGURE 1 Graph for multi-processing

IMPLEMENTATION

The script is made in C++ and the requests are simply made with the Curl library. Regarding the parallelizing processus, we simply cut the coordinates set into N (number of processus) jobs. Therefore, these jobs will only work with the attributed points.

FEATURES

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Page Layout

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CAPTIONS

Bibliography

Equations

TO DO'S

CONCLUSION

ACKNOWLEDGEMENTS

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