

TULIP Algorithm with Multilateration

Introduction

CBG is a technique used to calculate distance from delay based on constraints such as bestline, speed of internet (SOI) and speed of light (SOL). CBG with multilateration code uses CBG for delay to distance conversion before passing values onto multilateration algorithm. We modified CBG with multilateration code to use pure multilateration only. To accomplish this we did the following:

Generating CSV files from TULIP

Generated files from TULIP that contained information for multiple landmarks for each target in the following format:

TULIP output files (.csv), each line indicates a landmark

```
landmark1 ip, landmark1 name, distance1, lat1, long1, rtt1
landmark2 ip, landmark2 name, distance2, lat2, long2, rtt2
landmark3 ip, landmark3 name, distance3, lat3, long3, rtt3
...
...
```

Modifying files according to multilateration code requirements

We added target line at the top of each file, removed unnecessary information to generate files accordingly in the following format. A zero (0) in the first line indicates distance or delay (rtt) from the target to itself, which in any case will always be zero/nil. The script goes through Node_info.txt file to retrieve **lat**, **long** and **id** for targets and **id** for landmarks.

ModifyAndConvert.pl script output files (.txt), first line indicates a target, all other lines indicate a landmark

```
target-lat target-long id 0
landmark1-lat landmark1-long distance1 id
landmark2-lat landmark2-long distance2 id
landmark3-lat landmark3-long distance3 id
...
...
```

Delay to distance was converted using the formula mentioned below.

delay to distance conversion formula

```
distance = delay * 50
```

Executing multilateration code to generate resultant files

The .txt output files are used as input to multilateration code to generate resultant files containing information printed below. The first four lines give information related to the calculation, rest of the lines in the output files indicate the lat and longs of points defining the intersection region.

Multilateration code output files (.tulip)

```
id error-in-km
distance=to-nearest-landmark area-of-intersection-region
estimated-lat estimated-long
actual-lat actual-long
lat1 long1
lat2 long2
lat3 long3
...
...
```

This output format is the typical output format of multilateration code.