Bayesian Data Analysis of an Uber Driver's Optimal Daily Circuit

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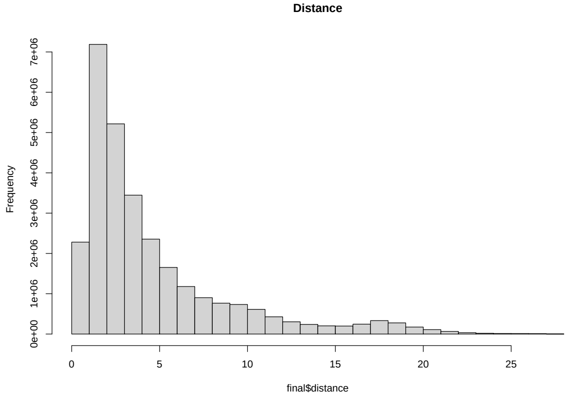
Contents

Uber Dataset

- 29 million rows

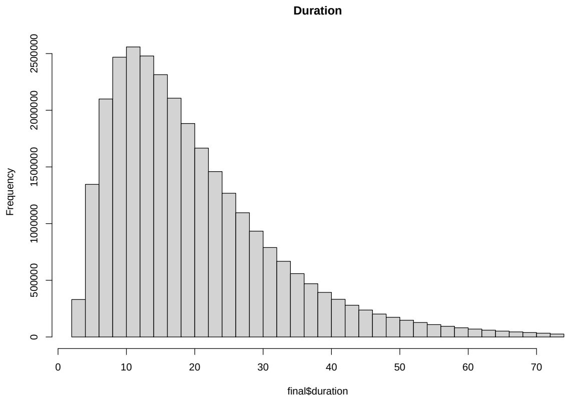
```
##      origin_taz destination_taz     pickup_datetime distan
## 1            7C              6A 2014-09-01 09:00:00     4.
## 2            7B              15 2014-09-01 18:00:00    10.
## 3            11              2A 2014-09-01 17:00:00     4.
## 4            3B              4A 2014-09-01 13:00:00     1.
## 5            2A              10 2014-09-01 14:00:00     8.
## 6            5B              4C 2014-09-01 12:00:00     1.
## 7            10              10 2014-09-01 14:00:00     1.
## 8            2A              7A 2014-09-01 03:00:00     5.
## 9            2B              3C 2014-09-01 11:00:00     1.
## 10            9              5B 2014-09-01 20:00:00    16.
## 11           2A              14 2014-09-01 01:00:00     9.
## 12           6B               8 2014-09-01 07:00:00     8.
## 13           15              14 2014-09-01 18:00:00    11.
## 14           4C               8 2014-09-01 10:00:00     7.
```

Distance Distribution



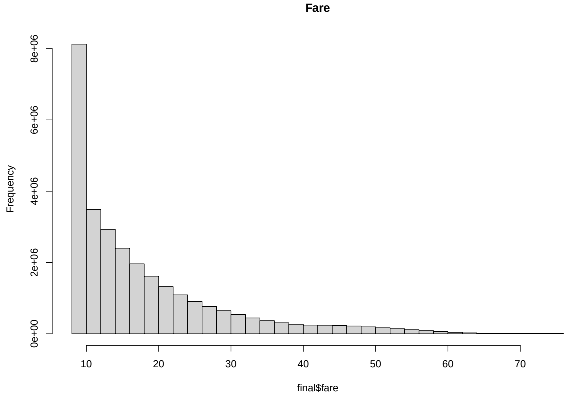

```
##     Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##     0.40    1.68    2.96    4.60    5.73   27.17
```

Duration Distribution



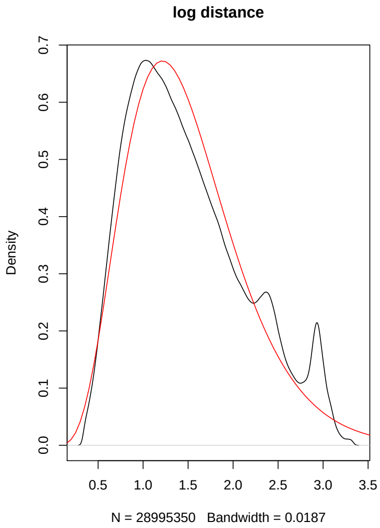

```
##     Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   2.867  10.800  16.833  19.774  25.617  73.750
```

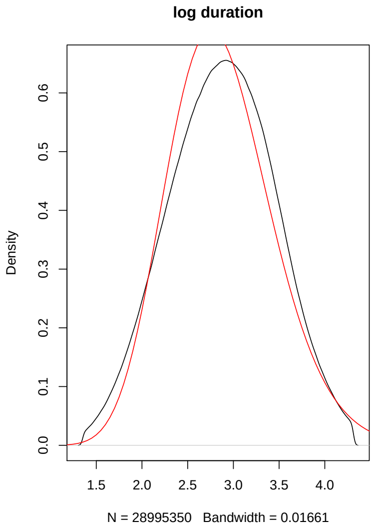
Fare Distribution




```
##     Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   8.000   9.533  13.960  17.724  21.829  75.823
```

Modeling log(Distance), log(Duration) with Gamma Priors





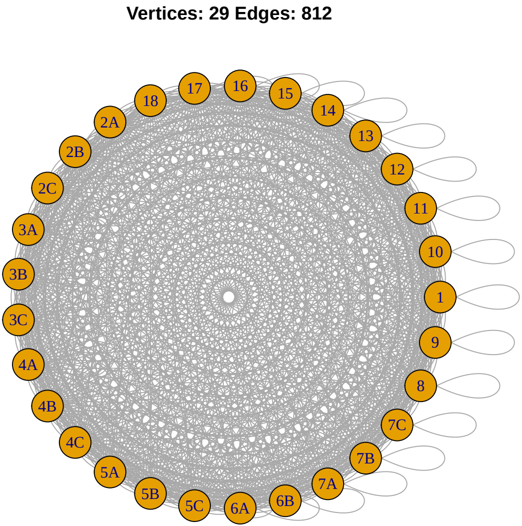
Uber Traffic as a Complete Graph

```
library(igraph)
```

```
##
## Attaching package: 'igraph'

## The following objects are masked from 'package:stats':
##
##     decompose, spectrum

## The following object is masked from 'package:base':
##
##     union
```

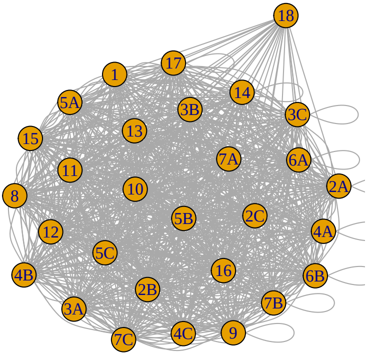
```
# make graph of original dataset
setwd("~/Desktop/695/uber-tlc-foil-response/uber-trip-data/
all_edges <- readRDS("all_edges.Rda")
n<- dim(all_edges)[1]
```

Uber Traffic as a Complete Graph

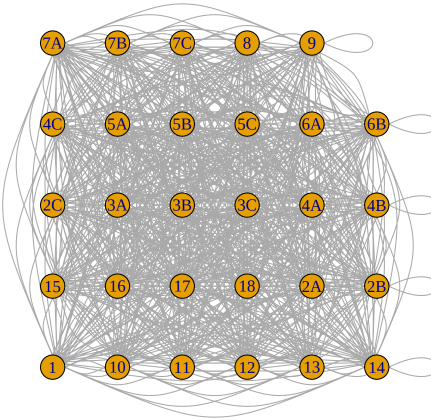


Uber Traffic as a Complete Graph

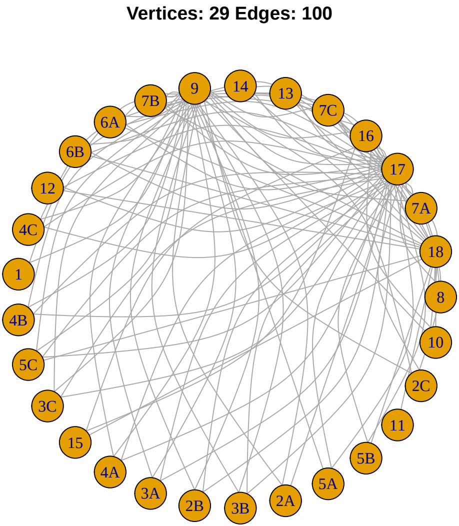
Vertices: 29 Edges: 812



Vertices: 29 Edges: 812



Subgraph induced by Top-100 (most lucrative) edges.



What's an Optimal Daily Circuit ?

- Circuit: Collection of edges
- Want a closed circuit aka Cycle or loop
- Want a "simple path" : each node visited only once

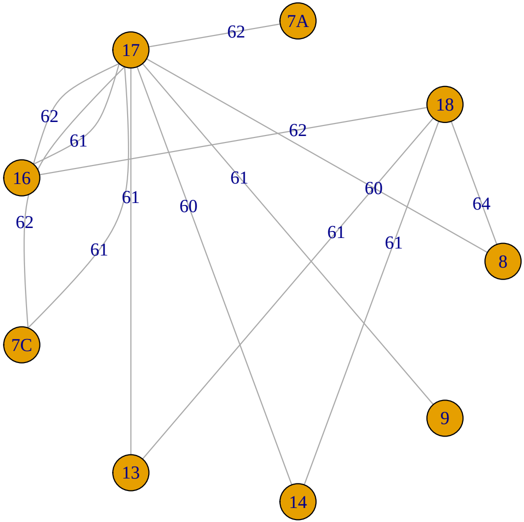
Optimal Circuit

- Circuit that makes the most money for the Uber Driver

Optimal Daily Circuit

- Driver works 9AM-5PM: 8 HOURS
- Make 1 Uber trip per hour
- Want an 8-cycle aka Simple Path with 8 Nodes aka 8-gon

Does a $60 per edge sparse graph contain an 8-gon ?



How many edges guarantee an 8-gon ?

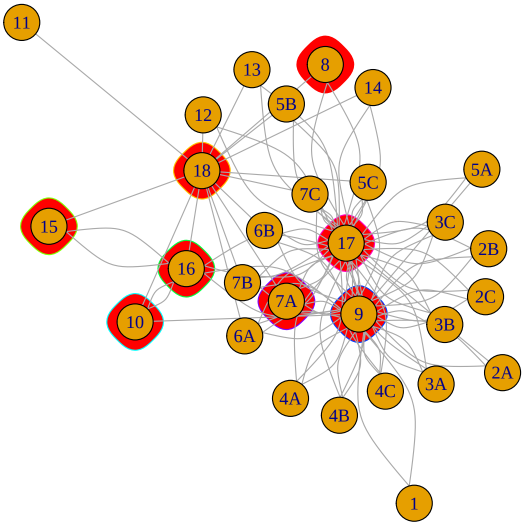
```
for(fares in seq(60,45,-2)) {
  highfare_matrix = edgematrix[as.numeric(edgematrix[,3]) >
  g2<-graph_from_edgelist(highfare_matrix[,1:2], directed=F
  lengths = c()

  for (v in V(g2)$name) {
    res = all_simple_paths(g2,v)
   lengths = c(lengths, max(sapply(1:length(res), function(
  }
  cat(sprintf("Fare: $%.0f, Longest path length: %.0f, Vert
}
```

```
## Fare: $60, Longest path length: 5, Vertices:9 Edges 13
## Fare: $58, Longest path length: 5, Vertices:10 Edges 18
## Fare: $56, Longest path length: 5, Vertices:13 Edges 24
## Fare: $54, Longest path length: 7, Vertices:15 Edges 31
```

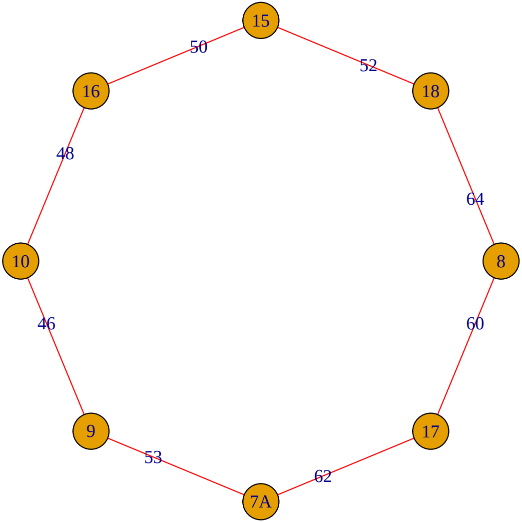
Finding the 8-gon

```
# visualize the graph with simple path of length 8
highfare_matrix = edgematrix[as.numeric(edgematrix[,3]) > 4
highfare_weights = round(as.numeric(highfare_matrix[,3]))
g3<-graph_from_edgelist(highfare_matrix[,1:2], directed=FAL
paths_of_length_8 = c()
found=FALSE
for (src in V(g3)$name) {
    res = all_simple_paths(g3,src)
    for(i in 1:length(res)) {
      l = length(res[[i]])
      last = res[[i]][l]$name
      d = distances(g3,v=last,to=src)
      if (l == 8 & d[1] == 1) {
          paths_of_length_8 = c(paths_of_length_8, res[[i]]
          print(res[[i]])
      }
```

The Optimal 8-gon!



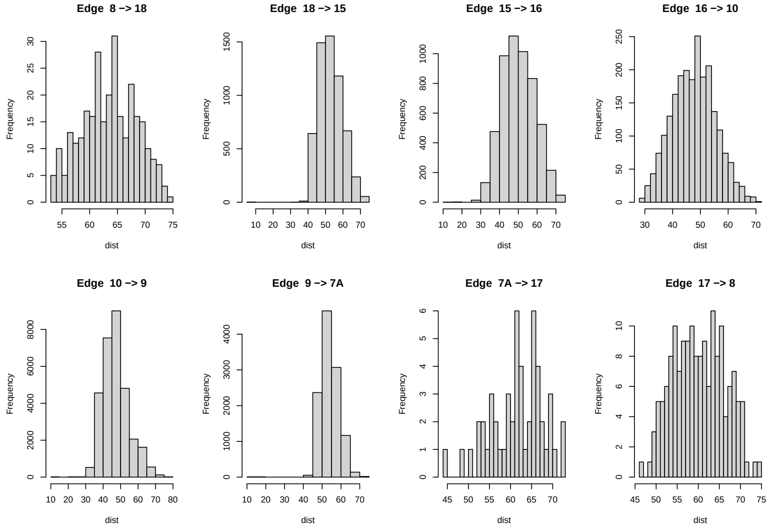
How much does the 8-gon Uber driver make ?



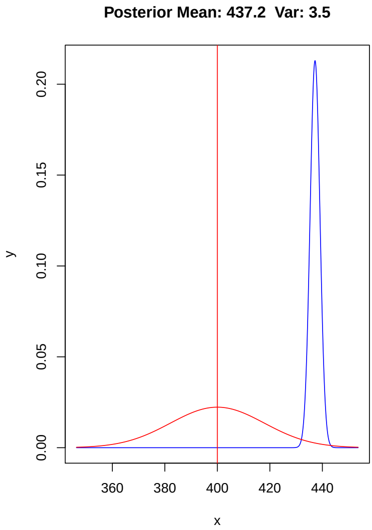
Optimal Circuit Summary Statistics

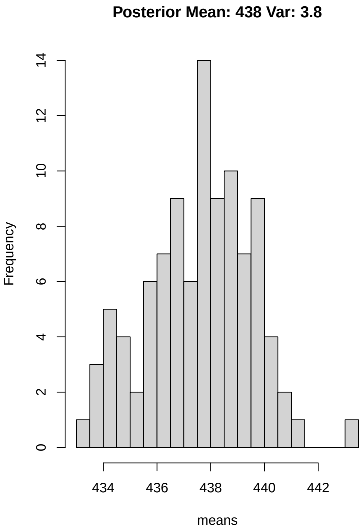
```
##    Src Dest  Mean Median Sigma   Var
## 1    8   18 63.54  63.69  4.90 23.97
## 2   18   15 53.06  52.44  6.71 45.06
## 3   15   16 50.18  49.72  8.65 74.84
## 4   16   10 47.70  47.86  7.69 59.07
## 5   10    9 47.20  46.39  7.40 54.79
## 6    9   7A 54.00  53.42  4.66 21.70
## 7   7A   17 61.56  61.96  6.22 38.72
## 8   17    8 60.19  59.89  6.04 36.47
```

Optimal Circuit: Edge Distributions



Posterior Mean of the Optimal Daily Circuit



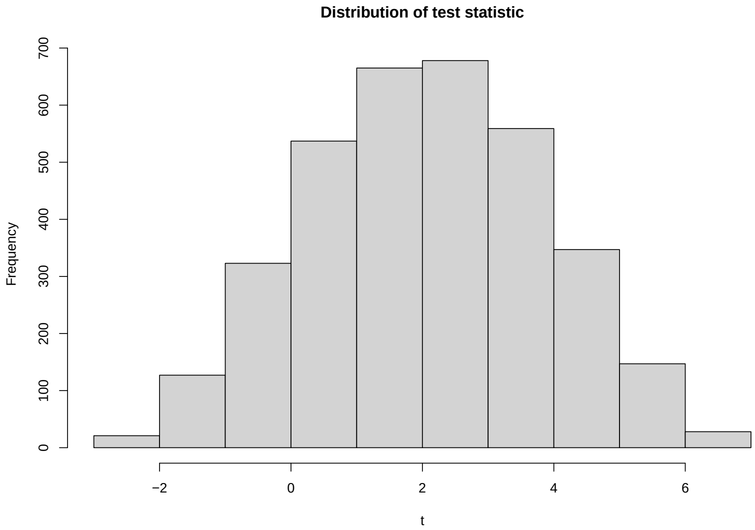


Comparing two Uber circuits via Confidence Distributions

- Professor Don Rubin: Fisher Randomization Test is a Stochastic Proof-By-Contradiction.
- FRT = distribution-free test to compare two (multimodal) Uber circuits
- Fisher Sharp Null compares individual potential outcomes $Y_i(1)\ vs\ Y_i(0)$ for every observation.
- An assignment is a boolean vector over two weeks.
- An assignment simply means on the given day, the Uber driver drove Circuit c2.
- A non-assignment means the wages would come from Ckt c1 aka Null Hypothesis.
- Compute the biweekly average and compare with the null hypothesis biweekly average
- This comparison is a simple difference test statistic.

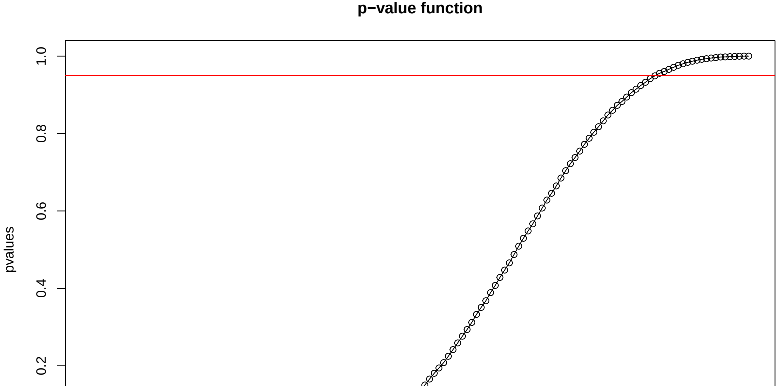
```
##          ab      bc      ca      ef      fg      ge  Ckt_c1  Ckt_c2
```

Comparing two Uber circuits via Confidence Distributions



Comparing two Uber circuits via Confidence Distributions

- For each theta, we find the proportion of assignments for which the test statistic does not exceed theta.
- A plot of p-value versus theta is the p-value function we seek, shown below with 95% Fisherian Interval (NOT Confidence Interval) in red.



WIP

- Alternate (non-Gaussian) modeling choices for Circuits
- Inference via MCMC & Variational Bayes

THANK YOU