Queueing Case

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Question 1

Approximately what fraction of time is Betty idle? Is Ben's estimate correct?

```
a$Pn
```

```
## [1] 0.2878019
```

Betty is idle 28.78% of the time. However Ben's estimate that she has too much downtime is inaccurate; her idle time is not a reflection of that estimate.

Question 2

Approximately how many calls are lost in an average hour due to a busy signal?

```
calls.lost = B_erlang(c=1, u =((80/8.489)/(1/mean(na.omit(datafile$Call.length)))))
percent(calls.lost)
```

```
## [1] "41.60%"
```

```
calls.lost*(1/mean(na.omit(datafile$Call.length)))
```

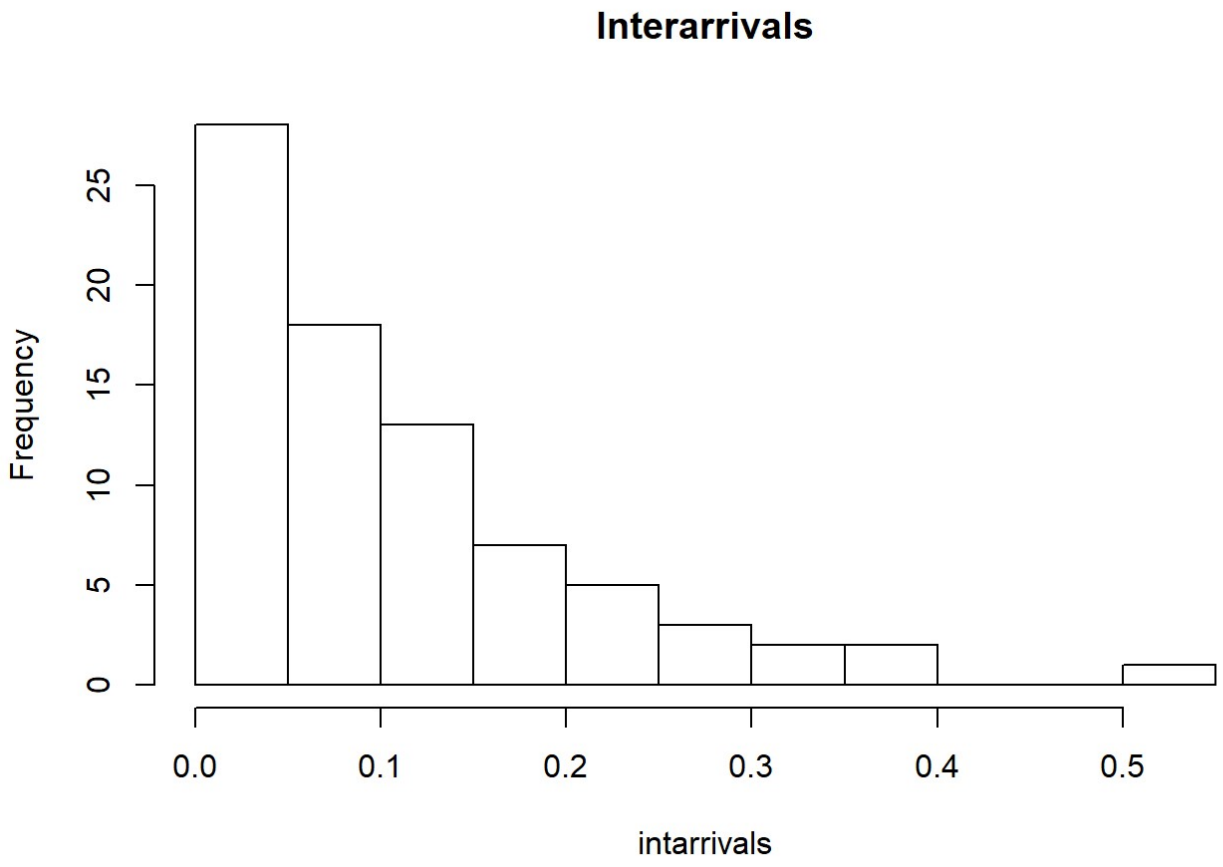
```
## [1] 5.50383
```

The Erlang loss calculation tell us that an average of 41.60% if callers are lost and cannot place an order. That represents about 5-6 callers per hour.

Question 3

Use the data to estimate the average arrival rate of all attempted calls to Catalog. Give an approximate 95% confidence interval for the estimate. Plot a frequency histogram of interarrival times. Does the distribution of interarrival times appear exponential?

```
intarrivals = c()
for (i in 2:80) {
  intarrivals[i] = datafile$Arrival.time[i] - datafile$Arrival.time[i -1]
}
hist(intarrivals, main = 'Interarrivals')
```




```
t.test(intarrivals)$"conf.int"
```

```
## [1] 0.08402998 0.12997255
## attr(,"conf.level")
## [1] 0.95
```

The 95% confidence interval for the average arrival rate of all attempted calls is between 0.084 and 0.130. Yes, the distribution of interarrival times does appear exponential.

Question 4

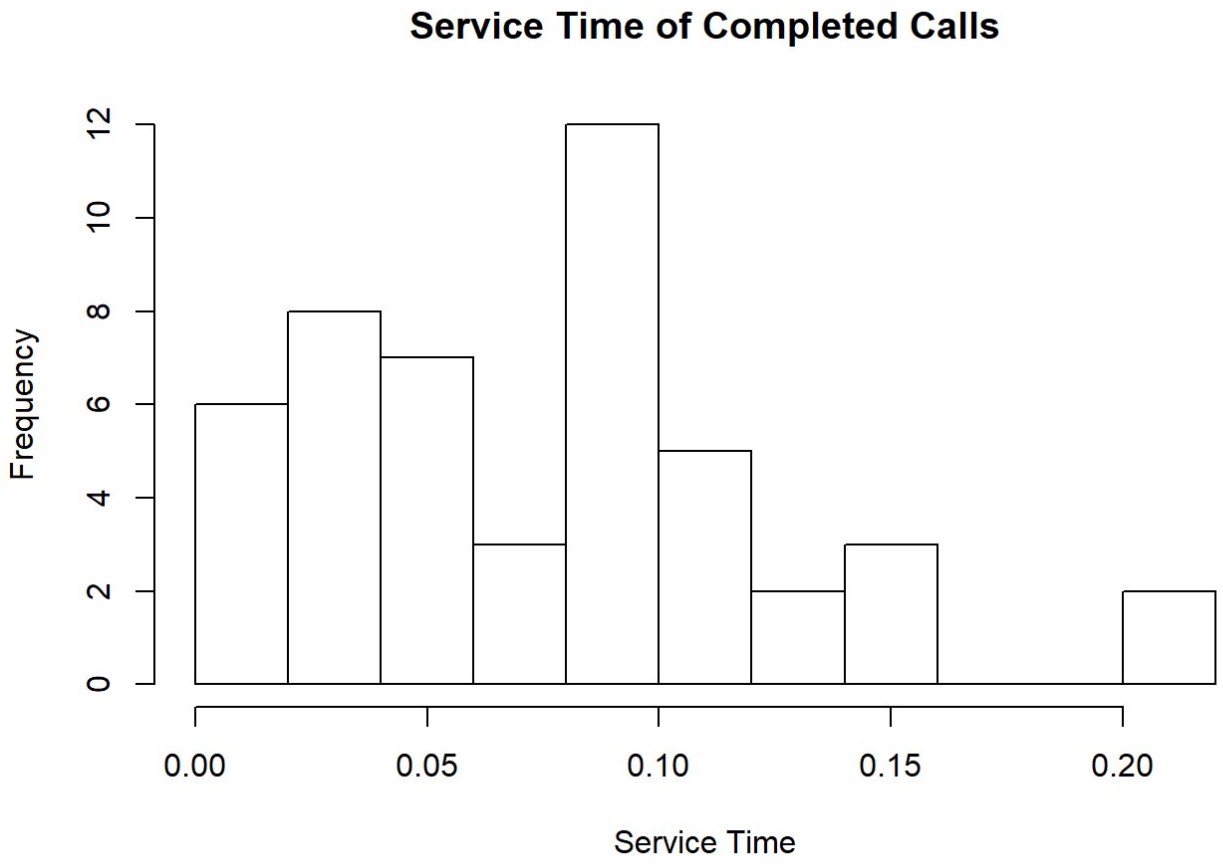
Use the data to estimate the average service rate of all completed calls. Give an approximate 95% confidence interval for the estimate. Plot a histogram of service times. Does the service time distribution appear to be exponential? Give an approximate 95% confidence interval for the average revenue per call.

```
#Mu/Service Rate
lengthOmit=na.omit(datafile$Call.length)
mu=1/mean(lengthOmit)

#Confidence interval and histogram
1/t.test(lengthOmit)$"conf.int"
```

```
## [1] 16.26243 11.15239
## attr(,"conf.level")
## [1] 0.95
```

```
hist(lengthOmit,main="Service Time of Completed Calls", xlab="Service Time",breaks=10)
#Service times are not exponential, but we can still model the exponential interarriva
l times with a Poisson process
```




```
#Revenue
revenueOmit=na.omit(datafile$Revenue)
avgRevenue=mean(revenueOmit)

#Confidence interval and histogram
t.test(revenueOmit)$"conf.int"
```

```
## [1] 32.06118 42.86673
## attr(,"conf.level")
## [1] 0.95
```

```
#hist(revenueOmit,main="Revenue per Completed Call")
```

The average service rate of all completed calls is 13.2311594. We can be 95% confident that the true average

service rate per server for completed calls is between 11.152385 and 16.2624328 calls per hour. We can see from the histogram above that service times do not appear to be exponential.

We can also be 95% confident that the average revenue per completed call is between $32.0611817 and $42.866735.

Question 5

Would you recommend that Catalog acquire additional phone lines and operators? Justify your response with a model and business interpretation. Justify your answer in enough detail so that Ben Gleason would be convinced of your recommendation.

```
serverPayHr=9
dayLength=9
costCall=1.5
costPhoneMo=40
#Up to four more lines can be added at $40/month
profit=.4
#No queue, customers without a server are lost to the system

lambda=length(datafile$Arrival.time)/datafile$Arrival.time[length(datafile$Arrival.tim
e)]
mu=1/mean(lengthOmit)

#Should they aquire additional servers
options(scipen=5,digits=4)
pr=as.data.frame(matrix(ncol=6,nrow=2))
for (numServ in 1:6){
pr[1,numServ]=B_erlang(c=numServ,u=lambda/mu)
pr[2,numServ]=(1-pr[1,numServ])*(mu*dayLength*(avgRevenue*profit*20))-(20*mu*dayLengt
h*costCall)-numServ*(20*serverPayHr*dayLength+costPhoneMo)
} #Assuming a 20-day weekday month and using average revenue and average service rate
--consider forecasting revenue and service rate
pr
```

V1 <dbl>	V2 <dbl>	V3 <dbl>	V4 <dbl>	V5 <dbl>	V6 <dbl>
0.416	0.129	0.02972	0.005265	0.0007494	0.00008895
15611.325	24192.465	26076.58613	25289.487488	23790.6366678	22154.20774991

2 rows

I would recommend that the company aquire two additional phone lines for a total of three phone lines. Currently with one server, around 41% of calls are going unanswered because the single phone line is already engaged when these calls are dialed. This is a substantial loss in potential revenue for the catalog. Due to the high proportion of unanswered calls, the idea of improving the mailing list could only benefit the catalog if they brought in customers who were likely to buy a higher dollar amount of goods. A much greater impact on the catalog's profit could be seen if they increased the number of phone lines so that calls are more likely to be answered. With three phone lines, their expected profit by phone line increases from $15,611 to $26,076.

Overall, this would not only benefit the bottom line of the catalog, but could raise the number of return customers and customer satisfaction.