Homework 4: Operations Management

DA 420

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Problem 1: Short Answers

Suppose you are the bank manager and your service goal is to realize wait times of 60 seconds of less, with wait times in excess of 120 seconds being considered intolerable. Based on Figure 6.1 through 6.6 (Call Center Operations for Monday, Tuesday, Wednesday, Thursday, Friday, and Sunday) in page 69 –71:

For each day, give an approximated percentage of the ribbons fall above the 120 seconds line. What kind of actions would you take? Please be as specific as possible.

Frequency of calls by day of week

Day of Week	Frequency
Sunday	6120
Monday	5722
Tuesday	6339
Wednesday	6289
Thursday	5785
Friday	1931
Saturday	857

Frequency of calls in February by hour and day of week

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Sunday	20	7	2	1	0	3	14	147	410	456	494	436	358	384	428	414	581	494	302	244	169	364	259	133
Monday	13	8	1	1	0	4	26	174	394	471	463	451	372	401	475	413	333	262	363	258	250	208	190	191
Tuesday	11	6	4	2	2	6	21	183	384	411	532	490	386	433	464	483	556	429	353	275	271	259	211	167
Wednesday	27	7	5	0	2	1	19	158	389	430	496	441	382	814	463	462	271	300	355	342	272	246	230	177
Thursday	25	2	2	0	0	5	21	147	327	400	513	440	381	374	471	495	579	402	295	213	212	162	174	145
Friday	26	2	7	3	5	3	10	94	304	296	274	297	286	186	80	26	8	4	5	3	8	3	0	1
Saturday	0	2	0	0	0	0	0	0	0	5	1	2	0	0	4	4	5	6	21	237	165	145	124	136

Frequency of calls in week by hour and day of week for first week of February 1999

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Sunday	7	2	1	1	0	2	6	34	124	129	128	130	102	83	109	108	155	103	64	43	50	62	47	42
Monday	4	3	1	0	0	1	9	50	134	118	110	127	92	106	109	96	88	68	120	69	87	61	49	45
Tuesday	2	2	1	0	0	4	9	58	124	131	158	130	114	132	133	147	157	115	81	89	66	75	51	55
Wednesday	7	2	2	0	1	1	5	41	119	104	125	125	102	494	145	117	64	68	83	104	66	68	49	46
Thursday	6	0	0	0	0	1	2	32	66	95	117	91	83	87	95	105	152	106	81	70	62	34	43	36
Friday	3	0	4	1	1	1	2	28	79	68	75	93	77	48	22	7	4	0	0	2	1	0	0	0
Saturday	0	2	0	0	0	0	0	0	0	3	0	2	0	0	1	0	1	0	5	66	37	37	27	28

Wait-time ribbon plots for the days that the bank was open during the first week of February 1999.

Monday Call Center Operations

Wait Time (Seconds) vs Hour of Day (24–Hour Clock)
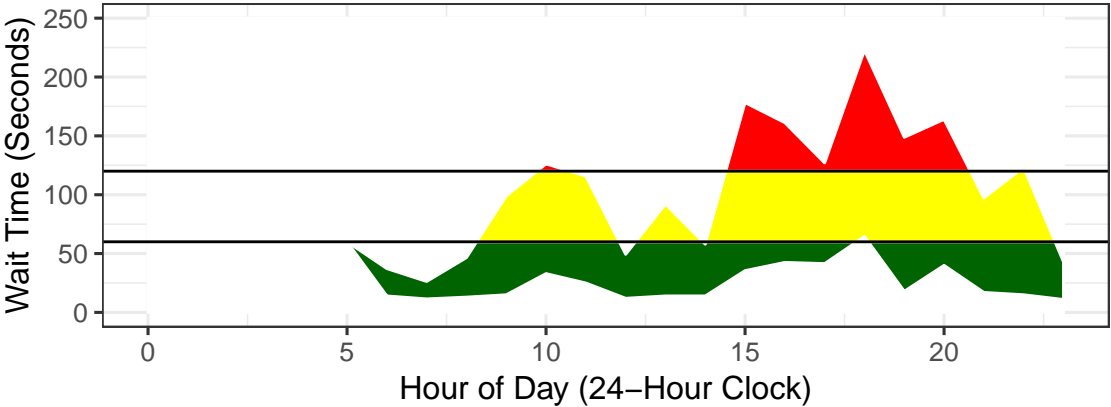
Hour:	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Servers:	0	0	0	0	0	0	1	5	8	8	9	10	10	10	9	10	6	5	7	5	5	4	4	4

	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Calls:	4	3	1	0	0	1	9	50	134	181	101	27	92	106	109	96	88	68	120	69	87	61	49	45
Served:	0	0	0	0	0	0	1	44	121	102	93	109	89	95	102	80	74	56	93	55	73	54	44	44
Dropped:	4	3	1	0	0	1	8	6	13	16	17	18	3	11	7	16	14	12	27	14	14	7	5	1

[1] "On Monday the approximate percentage that fall above the 120 seconds line is 10.5 %"

Tuesday Call Center Operations
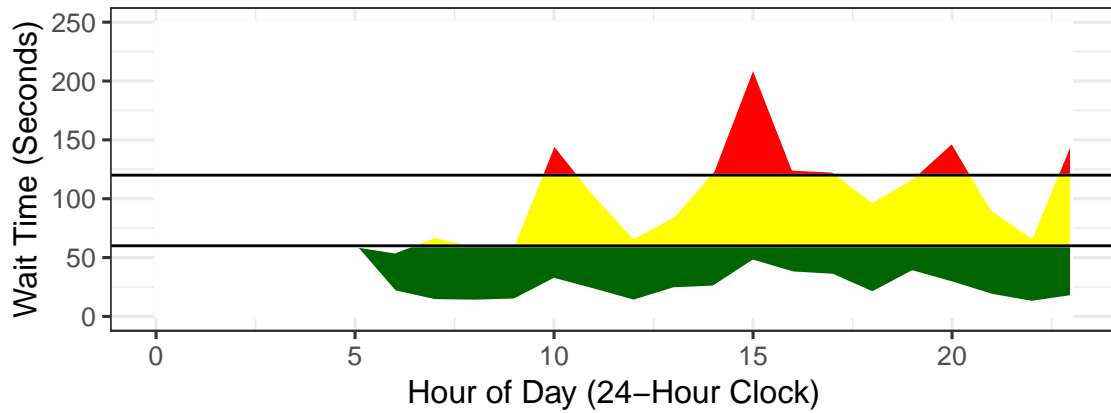
Hour:	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Servers:	0	0	0	0	0	0	1	6	9	9	9	9	9	11	10	11	9	8	8	7	7	6	5	3

	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Calls:	2	2	1	0	0	4	9	58	124	131	158	130	114	132	133	147	157	115	81	89	66	75	51	55
Served:	0	0	0	0	0	0	1	52	111	123	140	108	106	116	109	105	130	95	75	80	61	66	49	49
Dropped:	2	2	1	0	0	4	8	6	13	8	18	22	8	16	24	42	27	20	6	9	5	9	2	6

[1] "On Tuesday the approximate percentage that fall above the 120 seconds line is 9 %"

Wednesday Call Center Operations
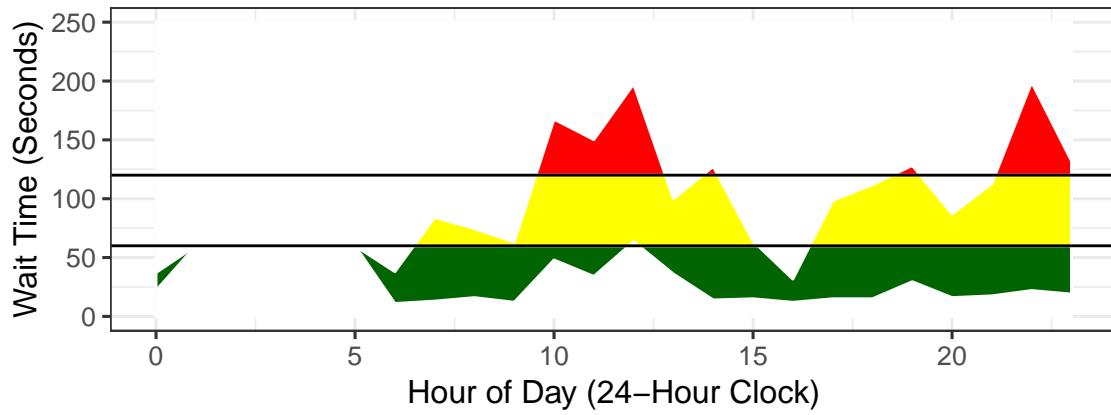
Hour:	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Servers:	0	0	0	0	0	0	1	6	7	9	9	9	9	10	11	11	8	7	7	7	7	6	3	3

	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Calls:	7	2	2	0	1	1	5	41	119	104	125	125	102	94	145	117	64	68	83	104	66	68	49	46
Served:	0	0	0	0	0	0	1	36	100	91	103	94	61	75	134	106	60	63	67	95	62	62	41	42
Dropped:	7	2	2	0	1	1	4	5	19	13	22	31	41	419	11	11	4	5	16	9	4	6	8	4

```
## [1] "On Wednesday the approximate percentage that fall above the 120 seconds line is  9.2 %"
```

4

Thursday Call Center Operations
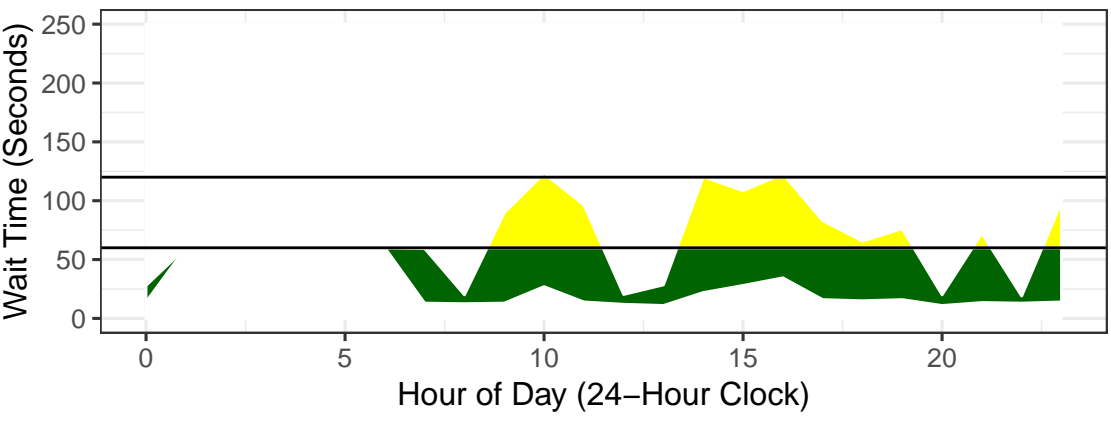
Hour:	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Servers:	0	0	0	0	0	0	0	4	8	8	9	10	10	10	8	10	8	6	7	8	7	6	5	5

	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Calls:	6	0	0	0	0	1	2	32	66	95	117	91	83	87	95	105	152	106	81	70	62	34	43	36
Served:	0	0	0	0	0	0	0	28	64	89	106	82	80	85	88	89	117	97	77	67	55	30	43	33
Dropped:	6	0	0	0	0	1	2	4	2	6	11	9	3	2	7	16	35	9	4	3	7	4	0	3

```
## [1] "On Thursday the approximate percentage that fall above the 120 seconds line is  5.3 %"
```

Friday Call Center Operations

Wait Time (Seconds) — y-axis: 0, 50, 100, 150, 200, 250

Hour of Day (24-Hour Clock) — x-axis: 0, 5, 10, 15, 20
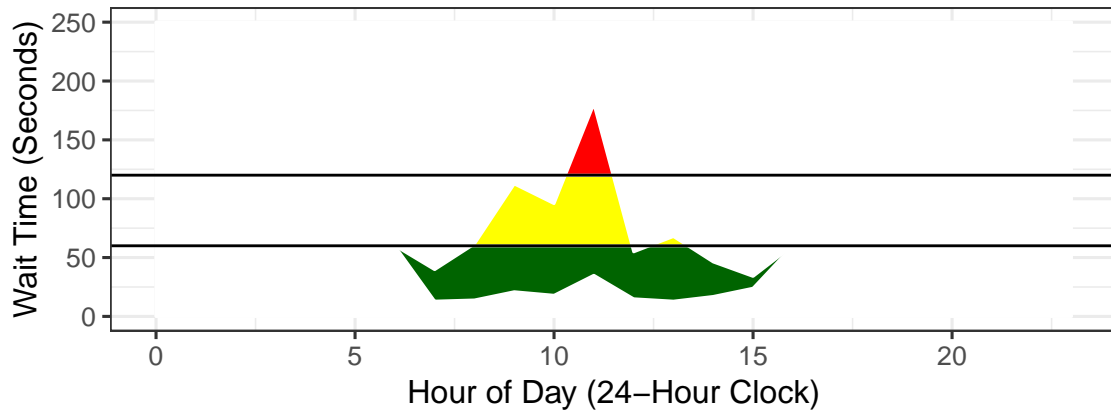
Hour:	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Servers:	0	0	0	0	0	0	1	5	6	7	6	7	7	5	0	0	0	0	0	0	0	0	0	0

	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Calls:	3	0	4	1	1	1	2	28	79	68	75	93	77	48	22	7	4	0	0	2	1	0	0	0
Served:	0	0	0	0	0	0	1	27	71	66	66	75	71	47	0	0	0	0	0	0	0	0	0	0
Dropped:	3	0	4	1	1	1	1	1	8	2	9	18	6	1	22	7	4	0	0	2	1	0	0	0

```
## [1] "On Friday the approximate percentage that fall above the 120 seconds line is  5.6 %"
```

Sunday Call Center Operations
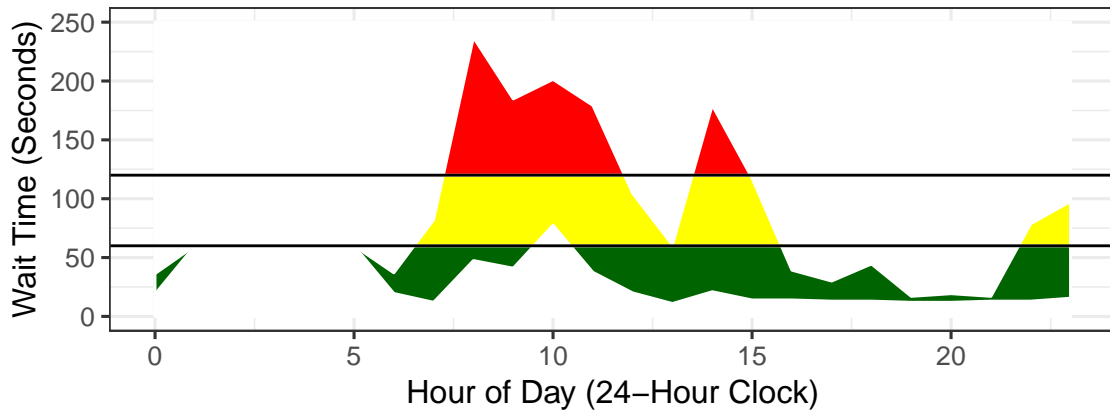
Hour:	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Servers:	0	0	0	0	0	0	0	3	7	7	7	8	9	10	12	14	12	10	9	9	9	9	6	5

	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Calls:	7	2	1	1	0	2	6	34	124	129	128	130	102	83	109	108	155	103	64	43	50	62	47	42
Served:	0	0	0	0	0	0	0	29	88	94	92	95	91	74	95	97	145	93	60	41	49	60	43	35
Dropped:	7	2	1	1	0	2	6	5	36	35	36	35	11	9	14	11	10	10	4	2	1	2	4	7

[1] "On Sunday the approximate percentage that fall above the 120 seconds line is 11.4 %"

Recomendations

Day of Week	Percentage
Monday	10.5
Tuesday	9
Wednesday	9.2
Thursday	5.3
Friday	5.6
Sunday	11.4

Sunday, Monday and Tuesday are the top 3 days where calls are recieved. Sunday, Monday and Wednesday are the top 3 days where percentage of the ribbons fall above the 120 seconds line. My recomendation is to apply labor planning (LP) problems to address staffing needs over a specific time period (i.e. shift). This models is useful when managers has flexibility in assigning workers to jobs that require overlapping or interchangeable talents. The bank manager would set a schedule that would minimize its total personnel costs while meeting service goals of wait times of 60 seconds or less and wait times not to excess 120 seconds. The objective is to minimize cost. There is a constraint for each shift of the day, stating that the number of people working at the bank during that shift should be at least the minimum number shown in the tables bellow.

From the chart above, on Sunday approximate 11.4% of calls fall above the 120 seconds line between 7AM and 12PM (Shift 2/3) and between 4PM and 5PM (Shift 4).

From the chart above, on Monday approximate 10.5% of calls fall above the 120 seconds line between 2PM and 9PM (Shift 2-7).

From the chart above, on Tuesday approximate 9.0% of calls fall above the 120 seconds line between 9:30AM - 10:30AM (Shift 2/3), between 2PM - 5PM (Shift 2-5), and between 7:30PM - 8:30PM (Shift 6-7).

The recomendation is develop an optimized model on the days with highest call volume since the budget is limited.

Problem 2: Short Answers

In page 75 of the textbook (Chapter 6), the author mentioned "optimal solution". Use your own words to answer the following questions, be sure to explain in details.

What is the optimal solution?

In linear program an optimal solution (i.e. feasible solution) with the largest objective function value (for a maximization problem) or lowest objective function value (for a minimization problem). It is possible for some problems to have more than one optimal solution.

The workforce scheduling is a minimization problem where workers must be scheduled such that resource needs are meet while minimizing costs.

How to find the optimal solutions?

To find optimal solutions, both queing theory and interger programing will be utilized The goal is to minimize total call operator costs while not exceeding constraints, hourly/shift needs. Interger programing is a good method to solvelLabor scheduling because it is a problem that must be solved on a regular basis. Once the objective function and constraints are established, the inputs can be changed each week/month to provide an updated schedule.

Objective Function:

Minimize total daily personnel cost = 252 * $Shift_1$ + 288 * $Shift_2$ + 180 * $Shift_3$ + 180 * $Shift_4$ + 180 * $Shift_5$ + 288 * $Shift_6$ + 288 * $Shift_7$ + 288 * $Shift_8$

Constraints:

For each hour, the available labor hours must be at least equal to the required labor hours.

Assumptions:

- Bank call center will be closed hours 00 through 05.

- Conversion rate from Israeli shekels to United States dollars was 1 ILS = 3.61 USD in June 2013.

Monday Call Center Arrival and Service Rates
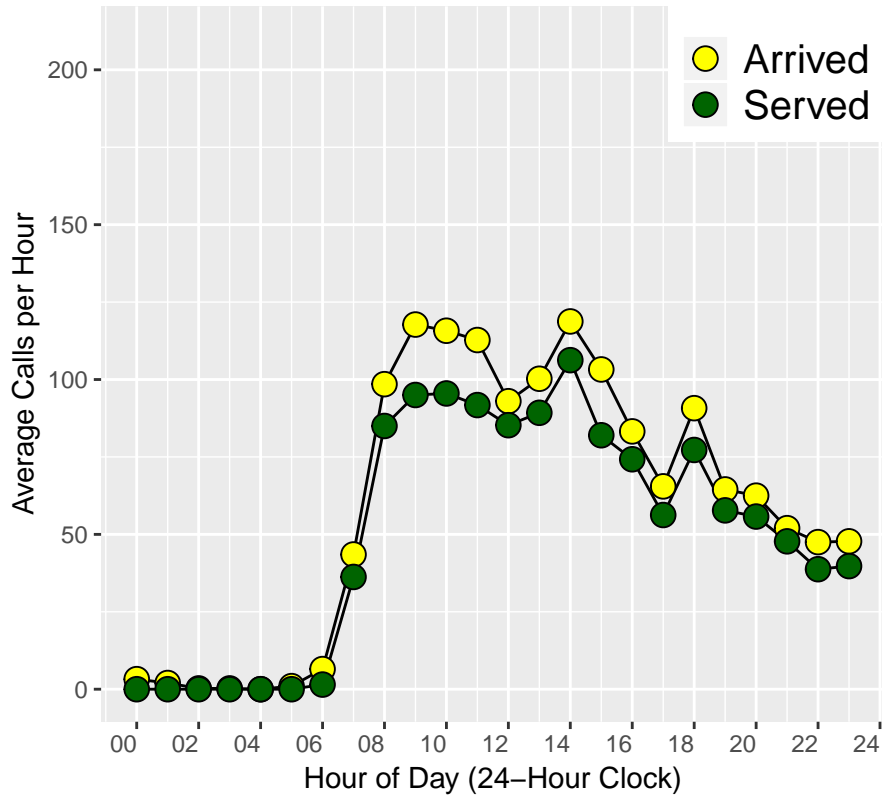

```
## 
##  Hourly service rate:[1] 15.58376
## 
##  Monday Hourly Operator Requirements:
##  [1] 0 0 0 0 0 0 1 4 8 9 9 9 8 8 9 8 7 6 8 6 6 5 4 5
## 
##  Monday Call Center Shift Constraint Matrix
##        Shift1 Shift2 Shift3 Shift4 Shift5 Shift6 Shift7 Shift8 Need
##  [1,]       1      0      0      0      0      0      0      0    0
##  [2,]       1      0      0      0      0      0      0      0    0
##  [3,]       1      0      0      0      0      0      0      0    0
##  [4,]       1      0      0      0      0      0      0      0    0
##  [5,]       1      0      0      0      0      0      0      0    0
##  [6,]       1      0      0      0      0      0      0      0    0
##  [7,]       0      1      0      0      0      0      0      0    1
##  [8,]       0      1      0      0      0      0      0      0    4
##  [9,]       0      1      1      0      0      0      0      0    8
## [10,]       0      1      1      0      0      0      0      0    9
## [11,]       0      1      1      1      0      0      0      0    9
## [12,]       0      1      1      1      0      0      0      0    9
## [13,]       0      0      1      1      1      0      0      0    8
## [14,]       0      0      1      1      1      0      0      0    8
## [15,]       0      0      0      1      1      1      0      0    9
## [16,]       0      0      0      1      1      1      0      0    8
## [17,]       0      0      0      0      1      1      1      0    7
## [18,]       0      0      0      0      1      1      1      0    6
## [19,]       0      0      0      0      0      1      1      1    8
## [20,]       0      0      0      0      0      1      1      1    6
```

```
## [21,]        0        0        0        0        0        0        1        1        6
## [22,]        0        0        0        0        0        0        1        1        5
## [23,]        0        0        0        0        0        0        0        1        4
## [24,]        0        0        0        0        0        0        0        1        5
##
##
##  Monday Call Center Summary
##
##   ShiftID StartTime ShiftDuration HourlyShiftSalary HourlyShiftCost
## 1        1         0             6                42             252
## 2        2         6             6                48             288
## 3        3         8             6                30             180
## 4        4        10             6                30             180
## 5        5        12             6                30             180
## 6        6         2             6                48             288
## 7        7         4             6                48             288
## 8        8         6             6                48             288
##   Solution ShiftCost
## 1        0         0
## 2        4      1152
## 3        5       900
## 4        3       540
## 5        4       720
## 6        2       576
## 7        1       288
## 8        5      1440
##
##
##  Monday Call Center Summary Minimum Cost Solution: 5616
```

Monday Call Center Needs and Optimal Workforce Schedule

Tuesday Call Center Arrival and Service Rates

##
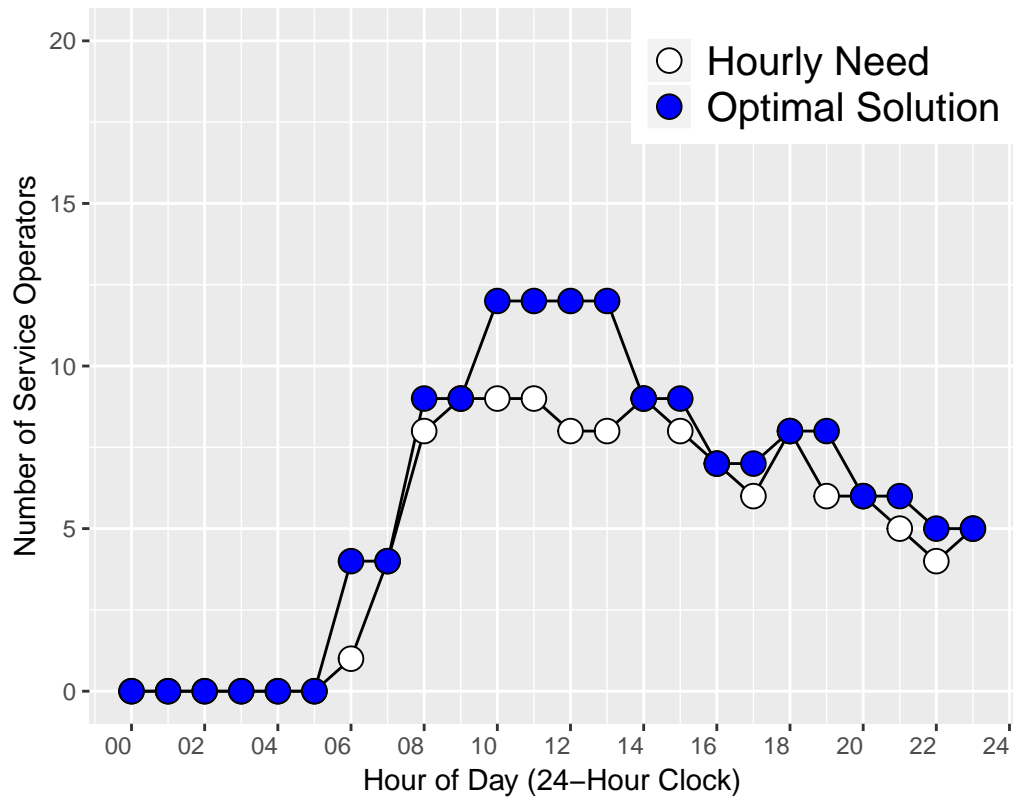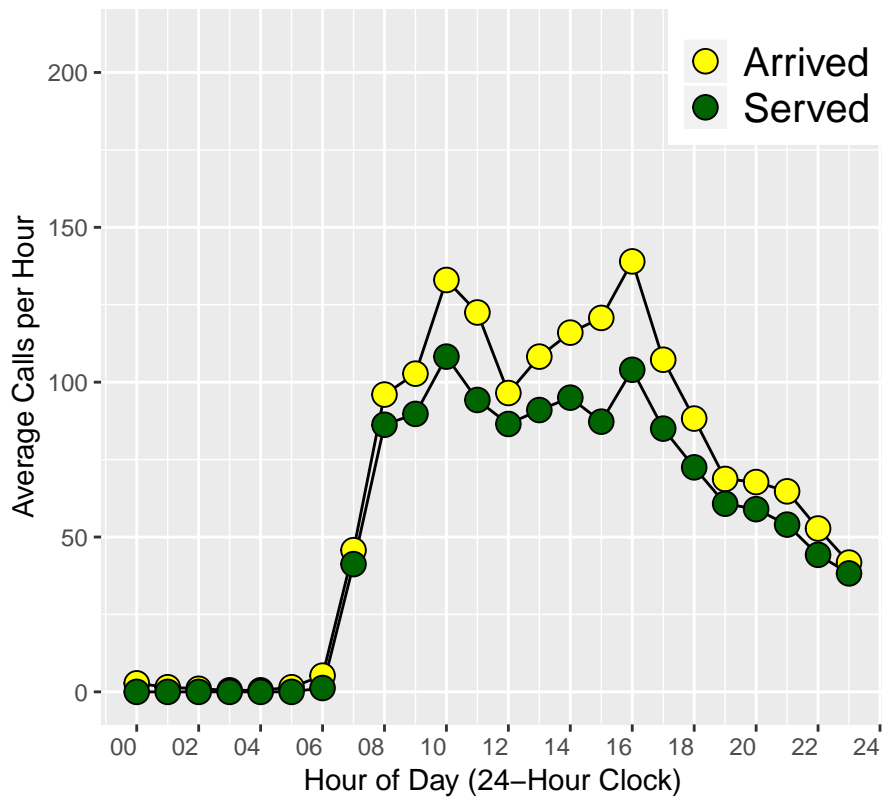
```
##  Hourly service rate:[1] 16.00215
##
##  Tuesday Hourly Operator Requirements:
##  [1]  0  0  0  0  0  0  1  4  8  8 10 10  8  9  9 10 11  9  7  6  6  6  5
## [24]  4
##
##  Tuesday Call Center Shift Constraint Matrix
##        Shift1 Shift2 Shift3 Shift4 Shift5 Shift6 Shift7 Shift8 Need
##  [1,]      1      0      0      0      0      0      0      0    0
##  [2,]      1      0      0      0      0      0      0      0    0
##  [3,]      1      0      0      0      0      0      0      0    0
##  [4,]      1      0      0      0      0      0      0      0    0
##  [5,]      1      0      0      0      0      0      0      0    0
##  [6,]      1      0      0      0      0      0      0      0    0
##  [7,]      0      1      0      0      0      0      0      0    1
##  [8,]      0      1      0      0      0      0      0      0    4
##  [9,]      0      1      1      0      0      0      0      0    8
## [10,]      0      1      1      0      0      0      0      0    8
## [11,]      0      1      1      1      0      0      0      0   10
## [12,]      0      1      1      1      0      0      0      0   10
## [13,]      0      0      1      1      1      0      0      0    8
## [14,]      0      0      1      1      1      0      0      0    9
## [15,]      0      0      0      1      1      1      0      0    9
## [16,]      0      0      0      1      1      1      0      0   10
## [17,]      0      0      0      0      1      1      1      0   11
## [18,]      0      0      0      0      1      1      1      0    9
## [19,]      0      0      0      0      0      1      1      1    7
## [20,]      0      0      0      0      0      1      1      1    6
## [21,]      0      0      0      0      0      0      1      1    6
## [22,]      0      0      0      0      0      0      1      1    6
## [23,]      0      0      0      0      0      0      0      1    5
## [24,]      0      0      0      0      0      0      0      1    4
##
##
##  Tuesday Call Center Summary
##
##    ShiftID StartTime ShiftDuration HourlyShiftSalary HourlyShiftCost
## 1       1         0             6                42             252
## 2       2         6             6                48             288
## 3       3         8             6                30             180
## 4       4        10             6                30             180
## 5       5        12             6                30             180
## 6       6         2             6                48             288
## 7       7         4             6                48             288
## 8       8         6             6                48             288
##    Solution ShiftCost
## 1         0         0
## 2         4      1152
## 3         6      1080
## 4         0         0
## 5         9      1620
## 6         1       288
## 7         1       288
## 8         5      1440
##
##
```

Tuesday Call Center Needs and Optimal Workforce Schedule

Wednesday Call Center Arrival and Service Rates
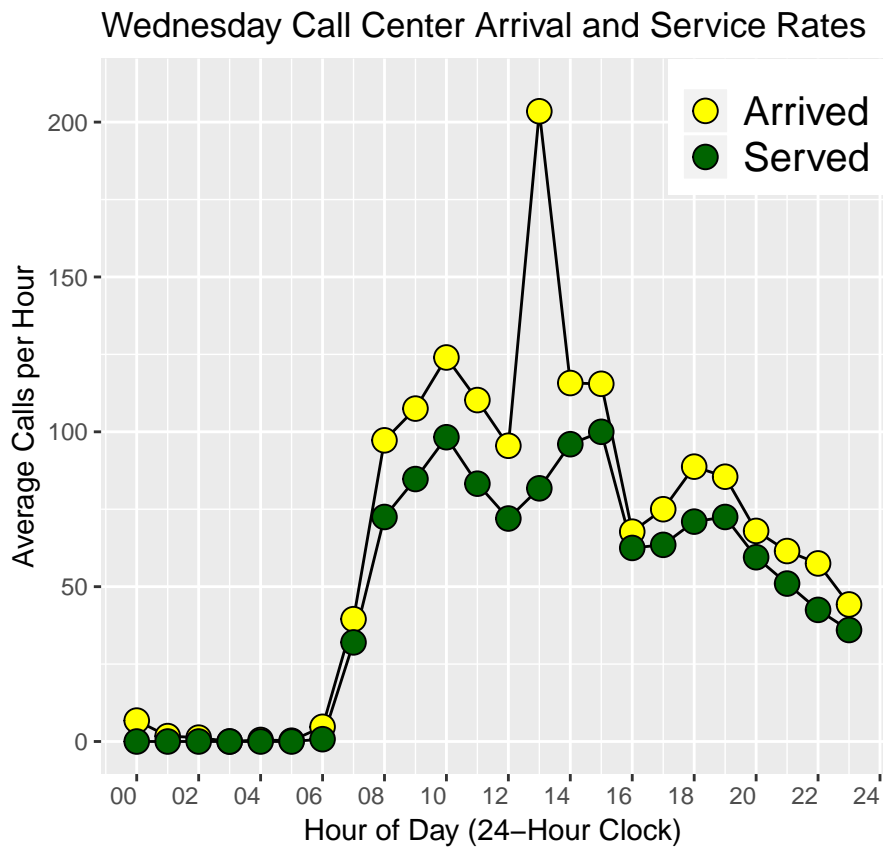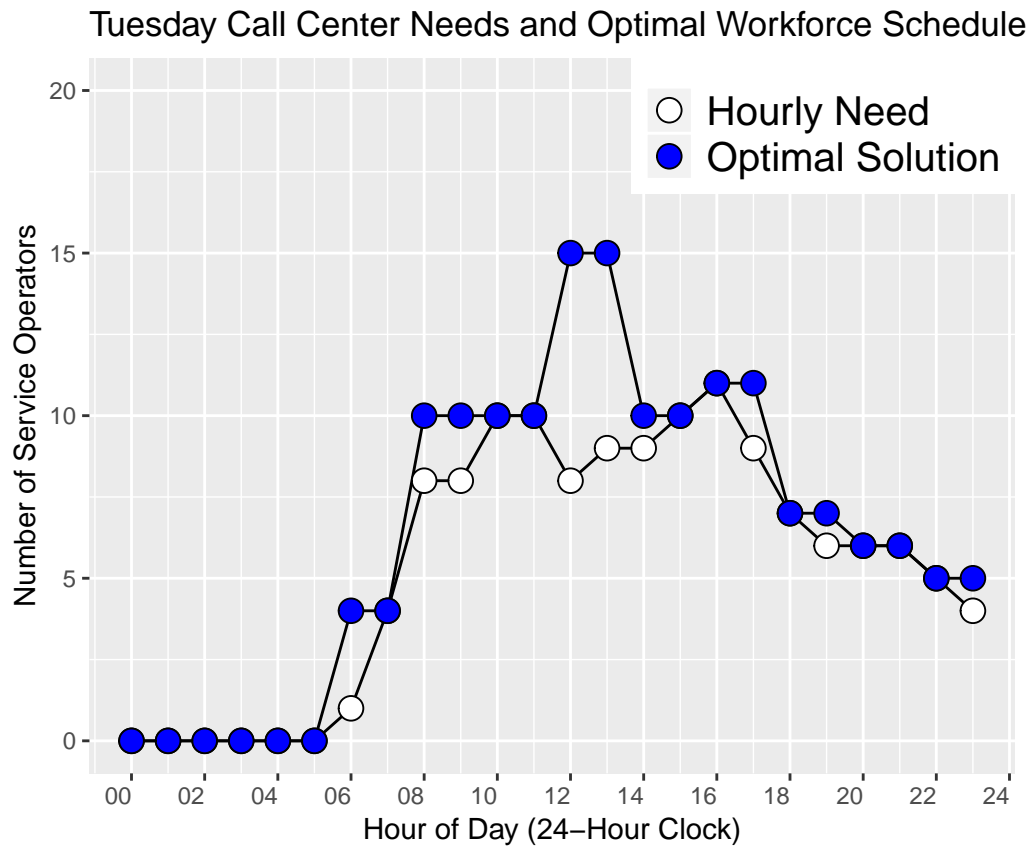
```
##
##  Hourly service rate:[1] 14.86443
##
##  Wednesday Hourly Operator Requirements:
##  [1]  0  0  0  0  0  0  1  4  8  9 10  9  8 16 10 10  6  7  8  8  6  6  5
## [24]  4
##
##  Wednesday Call Center Shift Constraint Matrix
##         Shift1 Shift2 Shift3 Shift4 Shift5 Shift6 Shift7 Shift8 Need
##  [1,]      1      0      0      0      0      0      0      0    0
##  [2,]      1      0      0      0      0      0      0      0    0
##  [3,]      1      0      0      0      0      0      0      0    0
##  [4,]      1      0      0      0      0      0      0      0    0
##  [5,]      1      0      0      0      0      0      0      0    0
##  [6,]      1      0      0      0      0      0      0      0    0
##  [7,]      0      1      0      0      0      0      0      0    1
##  [8,]      0      1      0      0      0      0      0      0    4
##  [9,]      0      1      1      0      0      0      0      0    8
## [10,]      0      1      1      0      0      0      0      0    9
## [11,]      0      1      1      1      0      0      0      0   10
## [12,]      0      1      1      1      0      0      0      0    9
## [13,]      0      0      1      1      1      0      0      0    8
## [14,]      0      0      1      1      1      0      0      0   16
## [15,]      0      0      0      1      1      1      0      0   10
## [16,]      0      0      0      1      1      1      0      0   10
## [17,]      0      0      0      0      1      1      1      0    6
## [18,]      0      0      0      0      1      1      1      0    7
## [19,]      0      0      0      0      0      1      1      1    8
## [20,]      0      0      0      0      0      1      1      1    8
## [21,]      0      0      0      0      0      0      1      1    6
## [22,]      0      0      0      0      0      0      1      1    6
## [23,]      0      0      0      0      0      0      0      1    5
## [24,]      0      0      0      0      0      0      0      1    4
##
##
##  Wednesday Call Center Summary
##
##   ShiftID StartTime ShiftDuration HourlyShiftSalary HourlyShiftCost
## 1       1         0             6                42             252
## 2       2         6             6                48             288
## 3       3         8             6                30             180
## 4       4        10             6                30             180
## 5       5        12             6                30             180
## 6       6         2             6                48             288
## 7       7         4             6                48             288
## 8       8         6             6                48             288
##   Solution ShiftCost
## 1        0         0
## 2        4      1152
## 3        8      1440
## 4        4       720
## 5        4       720
## 6        2       576
## 7        1       288
## 8        5      1440
##
```
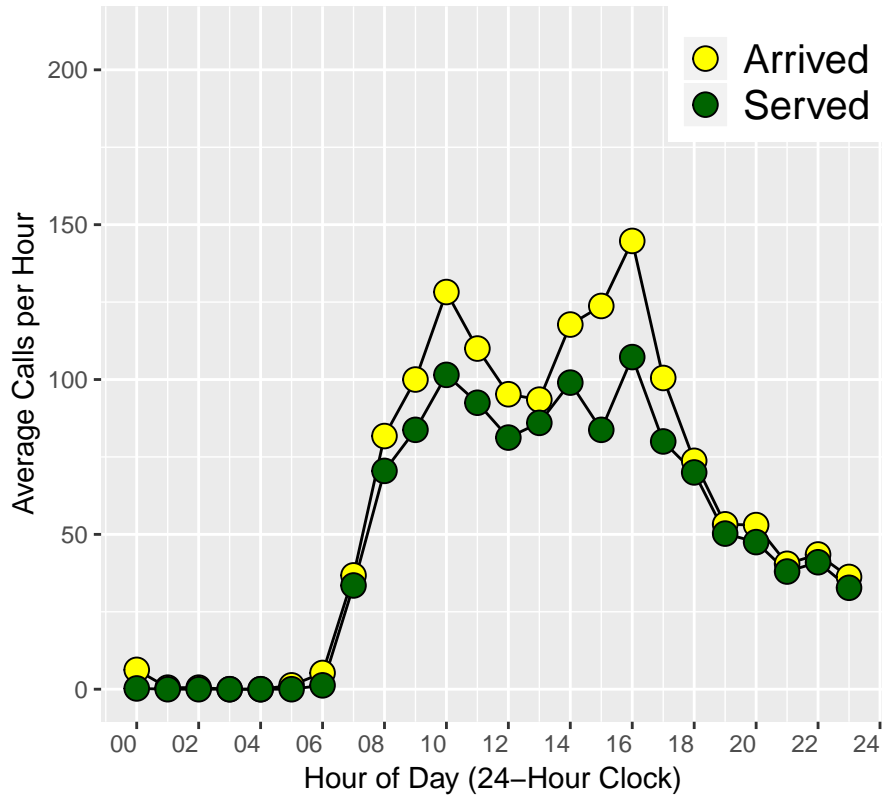
Wednesday Call Center Needs and Optimal Workforce Schedule
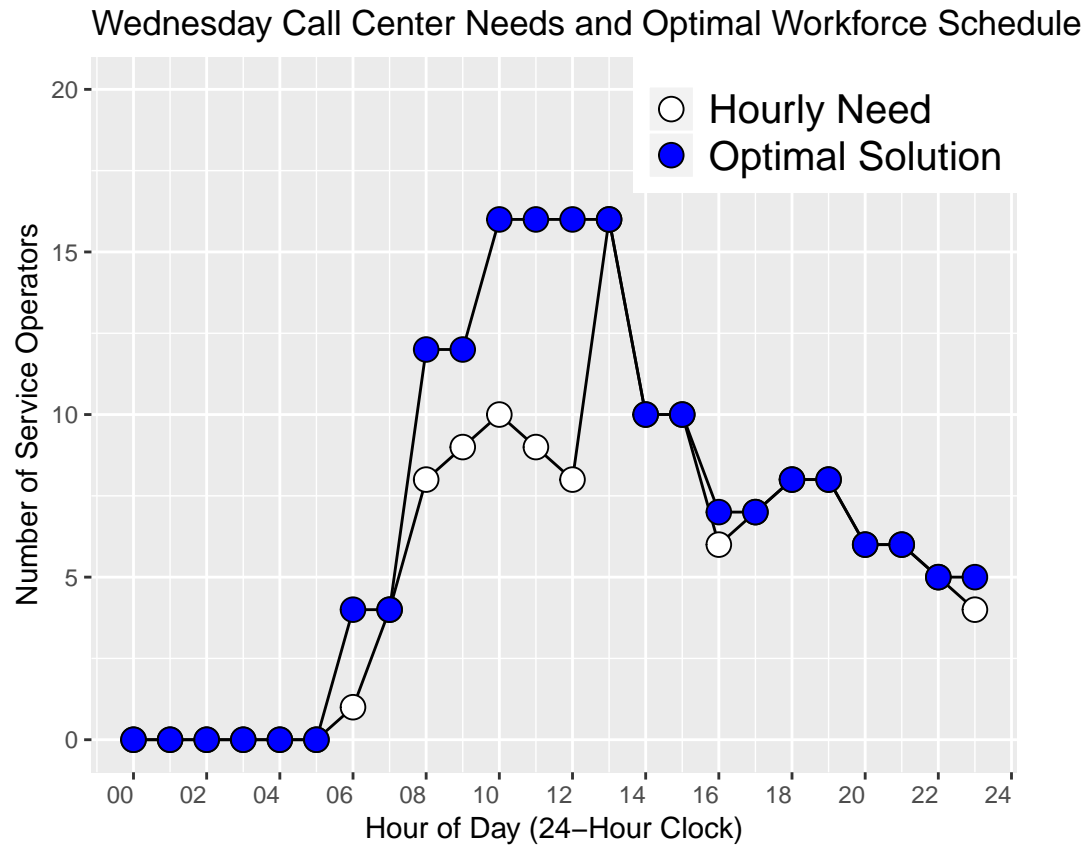
Thursday Call Center Arrival and Service Rates

```
## 
##  Hourly service rate:[1] 17.3122
## 
##  Thursday Hourly Operator Requirements:
##  [1]  0  0  0  0  0  0  1  4  7  8 10  8  7  7  9  9 11  8  6  5  5  4  4
## [24]  4
## 
##  Thursday Call Center Shift Constraint Matrix
##        Shift1 Shift2 Shift3 Shift4 Shift5 Shift6 Shift7 Shift8 Need
##  [1,]       1      0      0      0      0      0      0      0    0
##  [2,]       1      0      0      0      0      0      0      0    0
##  [3,]       1      0      0      0      0      0      0      0    0
##  [4,]       1      0      0      0      0      0      0      0    0
##  [5,]       1      0      0      0      0      0      0      0    0
##  [6,]       1      0      0      0      0      0      0      0    0
##  [7,]       0      1      0      0      0      0      0      0    1
##  [8,]       0      1      0      0      0      0      0      0    4
##  [9,]       0      1      1      0      0      0      0      0    7
## [10,]       0      1      1      0      0      0      0      0    8
## [11,]       0      1      1      1      0      0      0      0   10
## [12,]       0      1      1      1      0      0      0      0    8
## [13,]       0      0      1      1      1      0      0      0    7
## [14,]       0      0      1      1      1      0      0      0    7
## [15,]       0      0      0      1      1      1      0      0    9
## [16,]       0      0      0      1      1      1      0      0    9
## [17,]       0      0      0      0      1      1      1      0   11
## [18,]       0      0      0      0      1      1      1      0    8
## [19,]       0      0      0      0      0      1      1      1    6
```

```
## [20,]       0       0       0       0       0       1       1       1       5
## [21,]       0       0       0       0       0       0       1       1       5
## [22,]       0       0       0       0       0       0       1       1       4
## [23,]       0       0       0       0       0       0       0       1       4
## [24,]       0       0       0       0       0       0       0       1       4
##
##
##   Thursday Call Center Summary
##
##    ShiftID StartTime ShiftDuration HourlyShiftSalary HourlyShiftCost
## 1        1         0             6                42             252
## 2        2         6             6                48             288
## 3        3         8             6                30             180
## 4        4        10             6                30             180
## 5        5        12             6                30             180
## 6        6         2             6                48             288
## 7        7         4             6                48             288
## 8        8         6             6                48             288
##    Solution ShiftCost
## 1         0         0
## 2         4      1152
## 3         6      1080
## 4         0         0
## 5         9      1620
## 6         1       288
## 7         1       288
## 8         4      1152
##
##
##   Thursday Call Center Summary Minimum Cost Solution: 5580
```
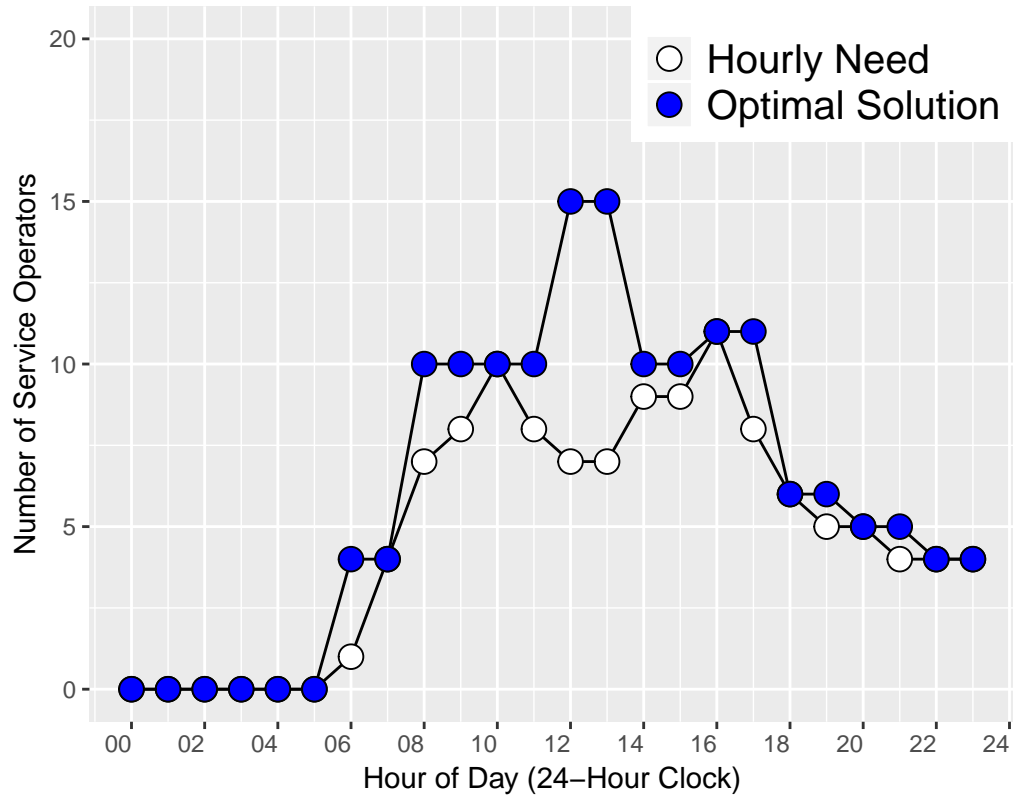
Thursday Call Center Needs and Optimal Workforce Schedule

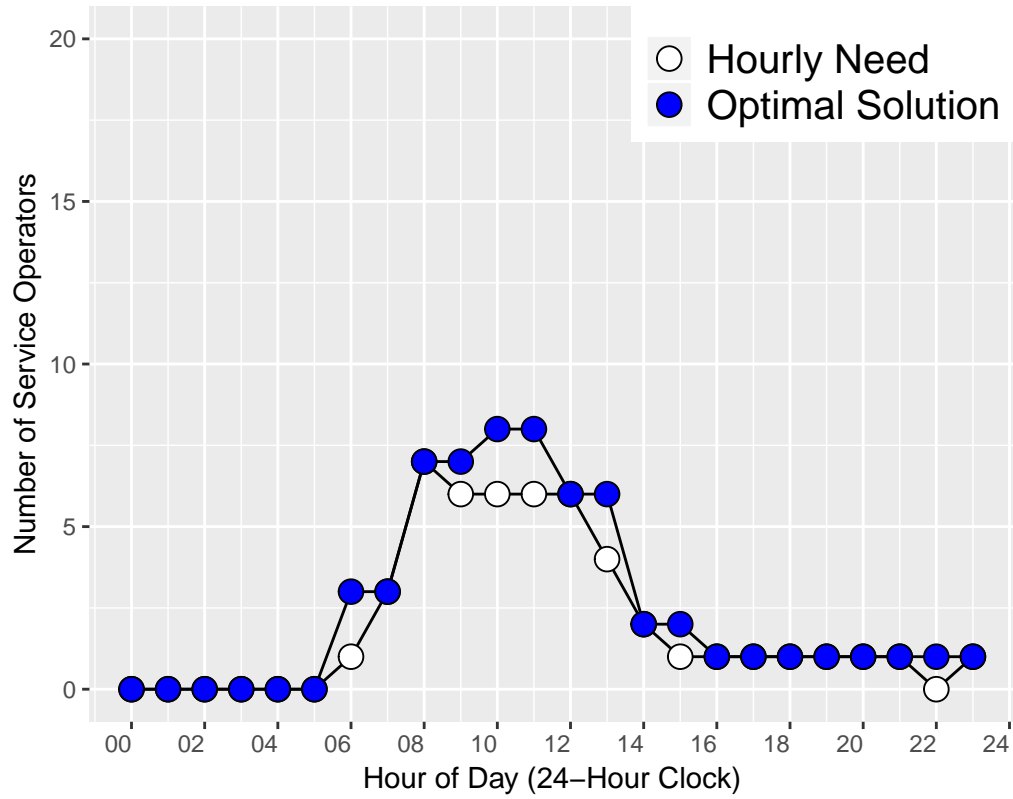Friday Call Center Arrival and Service Rates

##

```
##  Hourly service rate:[1] 16.45526
##
##  Friday Hourly Operator Requirements:
##  [1] 0 0 0 0 0 0 1 3 7 6 6 6 6 4 2 1 1 1 1 1 1 1 0 1
##
##  Friday Call Center Shift Constraint Matrix
##        Shift1 Shift2 Shift3 Shift4 Shift5 Shift6 Shift7 Shift8 Need
##  [1,]       1      0      0      0      0      0      0      0    0
##  [2,]       1      0      0      0      0      0      0      0    0
##  [3,]       1      0      0      0      0      0      0      0    0
##  [4,]       1      0      0      0      0      0      0      0    0
##  [5,]       1      0      0      0      0      0      0      0    0
##  [6,]       1      0      0      0      0      0      0      0    0
##  [7,]       0      1      0      0      0      0      0      0    1
##  [8,]       0      1      0      0      0      0      0      0    3
##  [9,]       0      1      1      0      0      0      0      0    7
## [10,]       0      1      1      0      0      0      0      0    6
## [11,]       0      1      1      1      0      0      0      0    6
## [12,]       0      1      1      1      0      0      0      0    6
## [13,]       0      0      1      1      1      0      0      0    6
## [14,]       0      0      1      1      1      0      0      0    4
## [15,]       0      0      0      1      1      1      0      0    2
## [16,]       0      0      0      1      1      1      0      0    1
## [17,]       0      0      0      0      1      1      1      0    1
## [18,]       0      0      0      0      1      1      1      0    1
## [19,]       0      0      0      0      0      1      1      1    1
## [20,]       0      0      0      0      0      1      1      1    1
## [21,]       0      0      0      0      0      0      1      1    1
## [22,]       0      0      0      0      0      0      1      1    1
## [23,]       0      0      0      0      0      0      0      1    0
## [24,]       0      0      0      0      0      0      0      1    1
##
##
##  Friday Call Center Summary
##
##    ShiftID StartTime ShiftDuration HourlyShiftSalary HourlyShiftCost
## 1        1         0             6                42             252
## 2        2         6             6                48             288
## 3        3         8             6                30             180
## 4        4        10             6                30             180
## 5        5        12             6                30             180
## 6        6         2             6                48             288
## 7        7         4             6                48             288
## 8        8         6             6                48             288
##    Solution ShiftCost
## 1         0         0
## 2         3       864
## 3         4       720
## 4         1       180
## 5         1       180
## 6         0         0
## 7         0         0
## 8         1       288
##
##
##  Friday Call Center Summary Minimum Cost Solution: 2232
```

Friday Call Center Needs and Optimal Workforce Schedule

Sunday Call Center Arrival and Service Rates

##
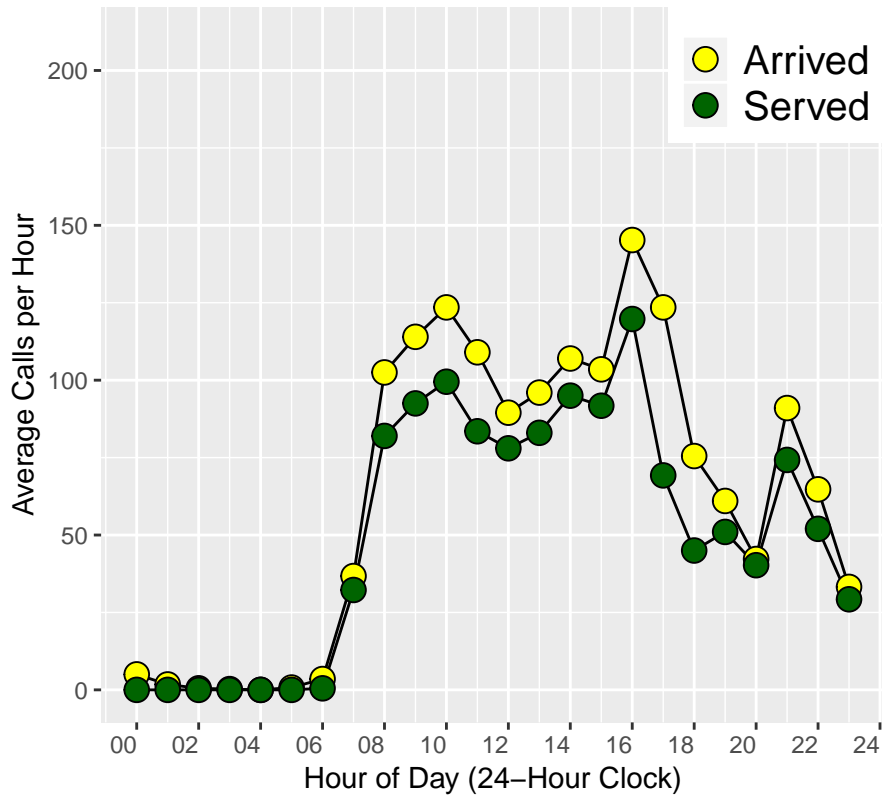
```
##  Hourly service rate:[1] 16.26824
##
##  Sunday Hourly Operator Requirements:
##  [1]  0  0  0  0  0  0  1  4  8  9 10  9  7  8  9  8 11 10  6  5  4  8  6
## [24]  3
##
##  Sunday Call Center Shift Constraint Matrix
##        Shift1 Shift2 Shift3 Shift4 Shift5 Shift6 Shift7 Shift8 Need
##  [1,]       1      0      0      0      0      0      0      0    0
##  [2,]       1      0      0      0      0      0      0      0    0
##  [3,]       1      0      0      0      0      0      0      0    0
##  [4,]       1      0      0      0      0      0      0      0    0
##  [5,]       1      0      0      0      0      0      0      0    0
##  [6,]       1      0      0      0      0      0      0      0    0
##  [7,]       0      1      0      0      0      0      0      0    1
##  [8,]       0      1      0      0      0      0      0      0    4
##  [9,]       0      1      1      0      0      0      0      0    8
## [10,]       0      1      1      0      0      0      0      0    9
## [11,]       0      1      1      1      0      0      0      0   10
## [12,]       0      1      1      1      0      0      0      0    9
## [13,]       0      0      1      1      1      0      0      0    7
## [14,]       0      0      1      1      1      0      0      0    8
## [15,]       0      0      0      1      1      1      0      0    9
## [16,]       0      0      0      1      1      1      0      0    8
## [17,]       0      0      0      0      1      1      1      0   11
## [18,]       0      0      0      0      1      1      1      0   10
## [19,]       0      0      0      0      0      1      1      1    6
## [20,]       0      0      0      0      0      1      1      1    5
## [21,]       0      0      0      0      0      0      1      1    4
## [22,]       0      0      0      0      0      0      1      1    8
## [23,]       0      0      0      0      0      0      0      1    6
## [24,]       0      0      0      0      0      0      0      1    3
##
##
##  Sunday Call Center Summary
##
##   ShiftID StartTime ShiftDuration HourlyShiftSalary HourlyShiftCost
## 1       1         0             6                42             252
## 2       2         6             6                48             288
## 3       3         8             6                30             180
## 4       4        10             6                30             180
## 5       5        12             6                30             180
## 6       6         2             6                48             288
## 7       7         4             6                48             288
## 8       8         6             6                48             288
##   Solution ShiftCost
## 1        0         0
## 2        4      1152
## 3        6      1080
## 4        0         0
## 5        9      1620
## 6        0         0
## 7        2       576
## 8        6      1728
##
##
```

Sunday Call Center Summary Minimum Cost Solution: 6156

Sunday Call Center Needs and Optimal Workforce Schedule