IE324 Simulation

2022 Spring Term Project

Round 3

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Changes in Model (different from stage 2)

Before starting optimization, we made changes in our models. First, we added 2 variables called DC1_Location_x, DC1_Location_y, DC2_Location_x and DC2_Location_y. They represent the coordinates of dispatch centers. Secondly we added 2 variables called DC1_vehicle_number and DC2_vehicle_number, they represent the number of vehicles in each center. Then added a schedule called DC1_schedule and DC2_schedule and set their values to the number of vehicle variables (DC1_vehicle_number and DC2_vehicle_number) and changed capacity in resource from fixed capacity to based on schedule.

Logic of the Optimization Model

To optimize profit we might change the location of dispatch centers and determine the vehicle number in each center without buying new cars while keeping the satisfaction rate as minimum 80%. To change the location of dispatch centers there are 4 possible scenarios:

1. DC1 and DC2 same
2. DC1 same, change DC2
3. DC2 same, change DC1
4. Change DC1 and DC2
    - 4.1. x- axis same, DC1 is up
    - 4.2. x- axis same, DC2 is up
    - 4.3. y- axis same, DC1 is on the right
    - 4.4. y- axis same, DC2 is on the right
    - 4.5. DC1 is on the right, DC1 is up
    - 4.6. DC1 is on the right, DC2 is up
    - 4.7. DC2 is on the right, DC1 is up
    - 4.8. DC2 is on the right, DC2 is up

Note that we divide scenario 4 into subgroups to prevent dispatch centers being in the same location.

We used OptQuest for optimization and started by setting the lower bound (LB) to 1 for DC1_Location_x, DC1_Location_y, DC2_Location_x and DC2_Location_y. Then we set the upper bound (UB) to 14 for DC1_Location_x, DC2_Location_x and to 17 for DC1_Location_y, DC2_Location_x.

We were going to set the lower bound to 0 and upper bound to 80 for vehicle number but we observed that the entity limit is being exceeded in Arena so we set different bounds for each scenario.

We make 50 simulation runs, 3 replications for scenario 1, 2, 3 and 150 simulation runs, 3 replications for scenario 4 since there are more possibilities. Now let's see our models and the results for the possible scenarios above.

Scenario 1- DC1 and DC2 same

Controls:

DC1_vehicle_number: LB: 15 and UB: 65

DC2_vehicle_number: LB: 15 and UB: 65

Response:

[Profit], [Number out], [Record satisfied], [Record partially satisfied]

Constraints:

(1*[Record satisfied]) + (0.5*[Record partially satisfied]) >= [Number out]*0.8

[DC1_vehicle_number] + [DC2_vehicle_number] <= 80

Objective:

maximize [Profit]

Output:

DC1_vehicle_number: 36

DC2_vehicle_number: 44

Profit: -$481.554,167

Scenario 2 - DC1 same, change DC2

Controls:

DC1_vehicle_number: LB: 30 and UB: 50

DC2_vehicle_number: LB: 30 and UB: 50

DC2_Location_x: LB: 1 and UB: 14

DC2_Location_y: LB: 1 and UB: 17

Response:

[Profit], [Number out], [Record satisfied], [Record partially satisfied]

Constraints:

(1*[Record satisfied]) + (0.5*[Record partially satisfied]) >= [Number out]*0.8

[DC1_vehicle_number] + [DC2_vehicle_number] <= 80

Objective:

maximize [Profit] - 2000

***Note that we subtract $2000 from profit since we change the location of one dispatch center. Instead of adding a constraint to prevent DC2 remaining at the same location we checked it manually and observed the location of DC2 changed.

Output:

DC1_vehicle_number: 33

DC2_vehicle_number: 47

DC2_Location_x: 11

DC2_Location_y: 8

Profit: -$451.128,50

Scenario 3 - DC2 same, change DC1

Controls:

DC1_vehicle_number: LB: 30 and UB: 50

DC2_vehicle_number: LB: 30 and UB: 50

DC1_Location_x: LB: 1 and UB: 14

DC1_Location_y: LB: 1 and UB: 17

Response:

[Profit], [Number out], [Record satisfied], [Record partially satisfied]

Constraints:

(1*[Record satisfied]) + (0.5*[Record partially satisfied]) >= [Number out]*0.8

[DC1_vehicle_number] + [DC2_vehicle_number] <= 80

Objective:

maximize [Profit] - 2000

***Note that we subtract $2000 from profit since we change the location of one dispatch center. Instead of adding a constraint to prevent DC1 remaining at the same location we checked it manually and observed the location of DC1 changed.

Output:

DC1_vehicle_number: 50

DC2_vehicle_number: 30

DC1_Location_x: 12

DC1_Location_y: 7

Profit: -$429.477,83

Scenario 4.1 - Change DC1 and DC2 : x- axis same, DC1 is up

Controls:

DC1_vehicle_number: LB: 30 and UB: 50

DC2_vehicle_number: LB: 30 and UB: 50

DC1_Location_x: LB: 1 and UB: 14

DC1_Location_y: LB: 1 and UB: 17

DC2_Location_x: LB: 1 and UB: 14

DC2_Location_y: LB: 1 and UB: 17

Response:

[Profit], [Number out], [Record satisfied], [Record partially satisfied]

Constraints:

(1*[Record satisfied]) + (0.5*[Record partially satisfied]) >= [Number out]*0.8

[DC1_vehicle_number] + [DC2_vehicle_number] <= 80

[DC1_Location_x] = [DC2_Location_x]

[DC1_Location_y] >= [DC2_Location_y] + 1

Objective:

maximize [Profit] - 4000

***Note that we subtract $4000 from profit since we change the location of two dispatch centers. Instead of adding a constraint to prevent them from remaining at the same locations we checked it manually and observed the location of both centers changed.

Output:

DC1_vehicle_number: 30

DC2_vehicle_number: 50

DC1_Location_x: 12

DC1_Location_y: 9

DC2_Location_x: 12

DC2_Location_y: 8

Profit: -$415.012,67

Scenario 4.2 - Change DC1 and DC2 : x- axis same, DC2 is up

Controls:

DC1_vehicle_number: LB: 30 and UB: 50

DC2_vehicle_number: LB: 30 and UB: 50

DC1_Location_x: LB: 1 and UB: 14

DC1_Location_y: LB: 1 and UB: 17

DC2_Location_x: LB: 1 and UB: 14

DC2_Location_y: LB: 1 and UB: 17

Response:

[Profit], [Number out], [Record satisfied], [Record partially satisfied]

Constraints:

(1*[Record satisfied]) + (0.5*[Record partially satisfied]) >= [Number out]*0.8

[DC1_vehicle_number] + [DC2_vehicle_number] <= 80

[DC1_Location_x] = [DC2_Location_x]

[DC2_Location_y] >= [DC1_Location_y] + 1

Objective:

maximize [Profit] - 4000

***Note that we subtract $4000 from profit since we change the location of two dispatch centers. Instead of adding a constraint to prevent them from remaining at the same locations we checked it manually and observed the location of both centers changed.

Output:

DC1_vehicle_number: 50

DC2_vehicle_number: 30

DC1_Location_x: 12

DC1_Location_y: 8

DC2_Location_x: 12

DC2_Location_y: 9

Profit: -$395.225,67

Scenario 4.3 - Change DC1 and DC2 : y- axis same, DC1 is on the right

Controls:

DC1_vehicle_number: LB: 30 and UB: 50

DC2_vehicle_number: LB: 30 and UB: 50

DC1_Location_x: LB: 1 and UB: 14

DC1_Location_y: LB: 1 and UB: 17

DC2_Location_x: LB: 1 and UB: 14

DC2_Location_y: LB: 1 and UB: 17

Response:

[Profit], [Number out], [Record satisfied], [Record partially satisfied]

Constraints:

(1*[Record satisfied]) + (0.5*[Record partially satisfied]) >= [Number out]*0.8

[DC1_vehicle_number] + [DC2_vehicle_number] <= 80

[DC1_Location_y] = [DC2_Location_y]

[DC1_Location_x] >= [DC2_Location_x] + 1

Objective:

maximize [Profit] - 4000

***Note that we subtract $4000 from profit since we change the location of two dispatch centers. Instead of adding a constraint to prevent them from remaining at the same locations we checked it manually and observed the location of both centers changed.

Output:

DC1_vehicle_number: 50

DC2_vehicle_number: 30

DC1_Location_x: 12

DC1_Location_y: 8

DC2_Location_x: 11

DC2_Location_y: 8

Profit: -$421.248,33

Scenario 4.4 - Change DC1 and DC2 : y- axis same, DC2 is on the right

Controls:

DC1_vehicle_number: LB: 37 and UB: 43

DC2_vehicle_number: LB: 37 and UB: 43

***Here we first try lower bound as 30 and upper bound as 50 but we get an error so we tried 35-45 but again we get an error. Then we choose 37-43.

DC1_Location_x: LB: 1 and UB: 14

DC1_Location_y: LB: 1 and UB: 17

DC2_Location_x: LB: 1 and UB: 14

DC2_Location_y: LB: 1 and UB: 17

Response:

[Profit], [Number out], [Record satisfied], [Record partially satisfied]

Constraints:

(1*[Record satisfied]) + (0.5*[Record partially satisfied]) >= [Number out]*0.8

[DC1_vehicle_number] + [DC2_vehicle_number] <= 80

[DC1_Location_y] = [DC2_Location_y]

[DC2_Location_x] >= [DC1_Location_x] + 1

Objective:

maximize [Profit] - 4000

***Note that we subtract $4000 from profit since we change the location of two dispatch centers. Instead of adding a constraint to prevent them from remaining at the same locations we checked it manually and observed the location of both centers changed.

Output:

DC1_vehicle_number: 37

DC2_vehicle_number: 43

DC1_Location_x: 11

DC1_Location_y: 8

DC2_Location_x: 12

DC2_Location_y: 8

Profit: -$395.165,167

Scenario 4.5 - Change DC1 and DC2 : DC1 is on the right, DC1 is up

Controls:

DC1_vehicle_number: LB: 30 and UB: 50

DC2_vehicle_number: LB: 30 and UB: 50

DC1_Location_x: LB: 1 and UB: 14

DC1_Location_y: LB: 1 and UB: 17

DC2_Location_x: LB: 1 and UB: 14

DC2_Location_y: LB: 1 and UB: 17

Response:

[Profit], [Number out], [Record satisfied], [Record partially satisfied]

Constraints:

(1*[Record satisfied]) + (0.5*[Record partially satisfied]) >= [Number out]*0.8

[DC1_vehicle_number] + [DC2_vehicle_number] <= 80

[DC1_Location_y] >= [DC2_Location_y] +1

[DC1_Location_x] >= [DC2_Location_x] + 1

Objective:

maximize [Profit] - 4000

***Note that we subtract $4000 from profit since we change the location of two dispatch centers. Instead of adding a constraint to prevent them from remaining at the same locations we checked it manually and observed the location of both centers changed.

Output:

DC1_vehicle_number: 30

DC2_vehicle_number: 50

DC1_Location_x: 13

DC1_Location_y: 8

DC2_Location_x: 11

DC2_Location_y: 7

Profit: -$413.406,83

Scenario 4.6 - Change DC1 and DC2 : DC1 is on the right, DC2 is up

Controls:

DC1_vehicle_number: LB: 35 and UB: 45

DC2_vehicle_number: LB: 35 and UB: 45

***Here we first set the lower bound to 30 and upper bound to 50 but we get an error so we narrowed the interval until there's no error.

DC1_Location_x: LB: 1 and UB: 14

DC1_Location_y: LB: 1 and UB: 17

DC2_Location_x: LB: 1 and UB: 14

DC2_Location_y: LB: 1 and UB: 17

Response:

[Profit], [Number out], [Record satisfied], [Record partially satisfied]

Constraints:

(1*[Record satisfied]) + (0.5*[Record partially satisfied]) >= [Number out]*0.8

[DC1_vehicle_number] + [DC2_vehicle_number] <= 80

[DC2_Location_y] >= [DC1_Location_y] +1

[DC1_Location_x] >= [DC2_Location_x] + 1

Objective:

maximize [Profit] - 4000

***Note that we subtract $4000 from profit since we change the location of two dispatch centers. Instead of adding a constraint to prevent them from remaining at the same locations we checked it manually and observed the location of both centers changed.

Output:

DC1_vehicle_number: 37

DC2_vehicle_number: 43

DC1_Location_x: 12

DC1_Location_y: 8

DC2_Location_x: 11

DC2_Location_y: 10

Profit: -$396.459,63

Scenario 4.7 - Change DC1 and DC2 : DC2 is on the right, DC1 is up

Controls:

DC1_vehicle_number: LB: 35 and UB: 45

DC2_vehicle_number: LB: 35 and UB: 45

***Here we first set the lower bound to 30 and upper bound to 50 but we get an error so we narrowed the interval until there's no error.

DC1_Location_x: LB: 1 and UB: 14

DC1_Location_y: LB: 1 and UB: 17

DC2_Location_x: LB: 1 and UB: 14

DC2_Location_y: LB: 1 and UB: 17

Response:

[Profit], [Number out], [Record satisfied], [Record partially satisfied]

Constraints:

(1*[Record satisfied]) + (0.5*[Record partially satisfied]) >= [Number out]*0.8

[DC1_vehicle_number] + [DC2_vehicle_number] <= 80

[DC1_Location_y] >= [DC2_Location_y] +1

[DC2_Location_x] >= [DC1_Location_x] + 1

Objective:

maximize [Profit] - 4000

***Note that we subtract $4000 from profit since we change the location of two dispatch centers. Instead of adding a constraint to prevent them from remaining at the same locations we checked it manually and observed the location of both centers changed.

Output:

DC1_vehicle_number: 35

DC2_vehicle_number: 45

DC1_Location_x: 4

DC1_Location_y: 9

DC2_Location_x: 10

DC2_Location_y: 8

Profit: -$416.528,33

Scenario 4.8 - Change DC1 and DC2 : DC2 is on the right, DC2 is up

Controls:

DC1_vehicle_number: LB: 30 and UB: 50

DC2_vehicle_number: LB: 30 and UB: 50

DC1_Location_x: LB: 1 and UB: 14

DC1_Location_y: LB: 1 and UB: 17

DC2_Location_x: LB: 1 and UB: 14

DC2_Location_y: LB: 1 and UB: 17

Response:

[Profit], [Number out], [Record satisfied], [Record partially satisfied]

Constraints:

(1*[Record satisfied]) + (0.5*[Record partially satisfied]) >= [Number out]*0.8

[DC1_vehicle_number] + [DC2_vehicle_number] <= 80

[DC2_Location_y] >= [DC1_Location_y] +1

[DC2_Location_x] >= [DC1_Location_x] + 1

Objective:

maximize [Profit] - 4000

***Note that we subtract $4000 from profit since we change the location of two dispatch centers. Instead of adding a constraint to prevent them from remaining at the same locations we checked it manually and observed the location of both centers changed.

Output:

DC1_vehicle_number: 30

DC2_vehicle_number: 50

DC1_Location_x: 12

DC1_Location_y: 7

DC2_Location_x: 14

DC2_Location_y: 9

Profit: -$394.719,50

Conclusion

In the original scenario each center has 40 vehicles and the location of dispatch center 1 (DC1) and dispatch center 2 (DC2) are (7, 13) and (10,4) respectively. The initial profit is -$481.705,00 with 3 replications. From the possible scenarios we observed that changing the location of both dispatch centers maximizes profit. We set DC1 to (12,7) with 30 vehicles and DC2 to (14,9) with 50 vehicles. The new profit is -$394.719,50. We increased the profit by $86.985,5.