Operations Research, Spring 2019 (107-2)
Case Assignment 1 (In-class Challenge)

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Though most information in this case is the same as that in Case 0, there are still differences. Please read this case carefully and provide your solutions according to this case. All the tables mentioned in this case are provided in the MS Excel file "OR107-2_case01_data.xlsx."

1 The company

Founded in 1983, NEC Taiwan is a subsidiary company of NEC Japan (originally Nippon Electric Company, now NEC Corporation). While it has many businesses, one major business of NEC Taiwan is to provide information system solutions for organizations and companies in Taiwan. Its customers include convenience stores, Taiwan Railways, Chunghwa Post, local financial institutes, etc. For example, many POS (point-of-sales) systems in convenience stores and all the ticketing gates and ticket-selling machines at Taiwan Railways stations are manufactured and maintained by NEC Taiwan.

To service around 15,000 customer operating locations (including stores, stations, post offices, etc.; for ease of exposition we will call them stores in the sequel), the Technical Support (TS) Division of NEC Taiwan operates twelve technical support facilities in Taiwan. Around 140 engineers are hired and distributed to these twelve locations to ensure the 24-hour services of the information systems in all the stores. Each store is assigned to one facility so that all the maintenance and repair works are done by the engineers in that facility. Table 1 lists the addresses, number of engineers, and the number of assigned stores of all the twelve facilities.[1]

[1] All information provided in this case, unless further noted, is retrieved in 2018. NEC Taiwan also has customer stores at outlying islands of Taiwan. Because all the services for these stores are not provided by the twelve facilities, in this case we consider only stores in the main island of Taiwan.

2 Shutting down and merging facilities

Ms. Janice Lai took the position of CEO of NEC Taiwan in 2018. At this moment, she is examining the facilities and engineers of the TS Division, whose current setting has been used for many years without adjustment. She finds something. For example, the Kaohsiung and Pingtung facilities are quite close to each other, and the Tamsui facility is also somewhat close to those in Nangang and Taoyuan. It makes sense to ask whether all these facilities are needed. As the operating costs of operating all the twelve facilities summed up to about 50 million dollars per year (cf. Table 2; all monetary values in this case are in New Taiwan Dollar), it would be nice if merging or adjusting some facilities may reduce operating costs. At the same time, however, Ms. Lai also observed that the service costs (including the cost of gasoline, depreciation of company cars, etc.) summed to about 40 million dollars. Obviously, if some facilities are shutdown, the total driving distance for serving customers will increase. As reducing operating cost will increase service cost, it may not always be worthwhile.

There are more issues other than costs that need to be considered. First of all, if any facility is shutdown, some facilities must be assigned more stores, which require more engineers. How to redistribute engineers at the same time? Whether a facility is big enough to accommodate redistributed engineers is also a concern. Moreover, NEC Taiwan signs service level agreements (SLA) with all its customers to guarantee that once any store calls NEC Taiwan to repair something, an NEC Taiwan engineer should arrive the store and complete the repair work within certain hours. For example, government agencies require eight hours, convenience stores require 24 hours, post offices require four hours, and local financial institutes require eight hours. A facility cannot be assigned to serve a store that is too far from it. Finally, to avoid complaints, no engineer may be fired even if some facilities are shutdown.

To help her analyze this problem and make a better decision, Ms. Lai collects some more data that may be relevant. Table 3 lists the numbers of engineers at each facility location and annual number of services from 2015 and 2017. Note that a store may call for services for multiple times in a year. Moreover, the driving times between all facility-store pairs are obtained through Google Maps API and presented in Table 4. Her staff estimates that driving one minute costs the company about six dollars, including everything. Finally, the numbers of service calls made by all stores in 2015 to 2017 are collected in Table 5.

3 Preparations

Ms. Lai understands that this problem cannot be easily solved. However, she feels that finding a better way to set facility locations, distribute engineers, and assign stores may save NEC Taiwan millions of dollars per year. She remembers that in the course "Business Decision Making" that she took in NTU EMBA, the professor mentioned about "Operations Research" as a powerful tool to solve a problem like this. She decides to create a team of operations researchers to work on this problem.

Given the information she collects and company policy, Ms. Lai decides to adopt the following rules in making her decisions. First, the number of services needed by a store in a year is assumed to be the maximum annual number of services out of 2015, 2016, and 2017. Moreover, each engineer in average may visit eight stores and complete eight services. As an engineer in average works 200 days in a year, it is estimated that an engineer may complete 1600 services per year. In other words, if a facility is expected to do 8000 services in a year for those stores assigned to it, it needs to have at least 10 engineers. Second, it is estimated that an engineer needs at least 20.5 m^2 of office space. In other words, if a facility's office size is 100 m^2, it may accommodate four but not five engineers. Finally, to meet the service level agreement (SLA), it is required that the driving time between a store and its assigned facility cannot be longer than 90 minutes.

The rule of cost calculation also needs to be specified. If a facility is open, its annual operating cost is estimated to be that number in the "Operating cost" column in Table 2. If it is shutdown, its annual operating cost becomes 0. The annual service cost of a facility is proportional to the total driving time required to serve all its assigned stores in a year. Note that one may need to visit a store multiple times. In practice, sometimes one engineer visits multiple stores in one route; to make their lives easier, Ms. Lai determines to ignore this possibility and assumes that all engineers directly return to their facilities after visiting one store. Note that the driving times in Table 4 are all one-way driving times. When one calculate the service cost of serving one store once, that driving time should be multiplied by two to obtain the two-way driving time.[2]

[2]In practice, determining those rules specified in this section can be the most difficult part. It requires data, data analysis, domain knowledge, and some subjective decisions based on experiences and insights. In this course, let's focus on modeling and algorithms and assume that some people have done that for you.

4 Your tasks

You are the leader of the Operations Research team. Now, use whatever method you like, make a suggestion to Ms. Lai about how to open/shutdown facilities, allocate engineers, and assign stores to facilities. Make your proposal by completing three things: an executive summary for the CEO, a detailed plan, and a description of your method.

1. (20 points) Write down a summary of your proposed plan in your report. In the report, do not repeat numbers that is already included in the spreadsheet. Instead, write an executive summary by summarizing relevant information that Ms. Lai, the CEO of your company, would be interested to know. Keep one thing in mind: A CEO is very busy! Of course, you should calculate and report the total cost. In short, summarize the *outcome* of your plan, but DO NOT include the detailed plan here. ***Limit this part to be no longer than one A4 page.***

   The points you earn in this part depends on the relevance, clearness, and easiness-to-read of your executive summary.

2. (40 points) Write down your detailed plan by filling in numbers into the spreadsheet *OR107-2_case01_ans.xlsx*. In that spreadsheet, you may modify only the values contained in those gray cells. ***Do not modify anything else.*** If you fail to follow this rule so that your submission cannot be graded automatically, you get no point in this part.

   As cost reduction is our objective, the points earned by a feasible plan is $40(\frac{z'-z}{z'-z^*})$, where z' is the current annual total cost, z is the annual total cost of your plan, and z^* is the maximum attainable profit.[3] If a plan is infeasible (e.g., allocating engineers to a facility that is shutdown), no point will be earned.

3. (40 points) Describe the method you design for this problem. Your description will be graded based on the logic of your method, extendability (e.g., can it still solve the problem efficiently when there are 50 facilities and 50000 stores?), and clarity. ***Limit this part to be no longer than two A4 pages.***

This case assignment counts for 5% of the semester grades.

[3]The instructing team knows z^* but will not reveal that to the students.

5 Submission rules

- **Teams.** Students should form teams to work on this case study. Each team should have three to four students. Each team should make only one submission.
- **Things to submit.** Please submit an MS Excel spreadsheet (for Problem 2 above) and a PDF file (for Problem 1 and 3 above). Include the student IDs and names of all team members in both files.
- **Where to submit.** Please submit both files to NTU COOL. Each team should make only one submission, i.e., only one student should make a submission.
- **Deadline.** The deadline of this assignment (for both the report and files) is 2:00 pm, February 25, 2019. Works submitted between 2:00 pm and 3:00 pm will get 10 points deducted as a penalty. Submissions later than 3:00 pm will not be accepted.

6 Final note

As you have not really learned anything from this course, this case assignment is designed for you to understand this problem and experience the difficulties of real-world decision problems. We do not expect you to perfectly solve this problem. Therefore, as long as you provide a reasonable way to find a reasonable solution, you do not need to worry too much about your grades. Nevertheless, trying to solve challenging problems is always interesting. Maybe you may find an optimal solution! If you have some free time, why not give it a try?