系所組別： 製造資訊與系統研究所乙組
考試科目： 生產管理

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1. [24%] Suppose a factory has to produce n different products on a single machine and the demands for all products are equal (i.e. to produce the same amount of products). Given an $n \times n$ setup time matrix $S = [s_{ij}]$, where s_{ij} represents the setup time required to process produce j right after product i. Then, one can calculate the time to conduct each possible cyclic manufacturing on S. For example, if $n = 4$, and $s_{14} = 2$, $s_{42} = 3$, $s_{23} = 5$, and $s_{31} = 1$, then a cyclic manufacturing process that produce product $1 \to 4 \to 2 \to 3 \to 1$ takes $2 + 3 + 5 + 1 = 11$ units of time. Answer the following questions:

(a) [5%] How many possible cyclic manufacturing processes are there at most? (your answer should be a function of n). Explain your answer. (answer without explanation get at most 1 point)

(b) [3%] Verify your answer in (a) for the case $n = 4$.

(c) If you treat each product as a node, you can draw a graph G composed of n nodes and $C_2^n = \frac{n(n-1)}{2}$ arcs, where an arc (i,j) denotes a consecutive processing order that product j is processed right after product i. Thus s_{ij} becomes the length of (i,j). Let $x_{ij} = 1$ represent arc (i,j) is selected, and $x_{ij} = 0$, otherwise. Then, to identify a cyclic manufacturing process with minimum total setup time becomes to identify a shortest Hamiltonian cycle (i.e. a closed walk, or tour that visits every node exactly once) in G. Let c denote a Hamiltonian cycle. Professor Chen suggests to solve this problem by converting it into an assignment problem, which can be solved by Hungarian method.

(c.1) [5%] Explain how to convert the original problem to a problem similar to an assignment problem. (hint: write the math formulation for an assignment problem, using suitable variables)

(c.2) [3%] Does the shortest Hamiltonian cycle problem belong to a linear programming problem (LP) or an linear integer programming problem (ILP)? why or why not?

(c.3) [3%] Does the assignment problem belong to a linear programming problem (LP)? why or why not?

(c.4) [5%] Based on your answers in (c.2) and (c.3), do you agree with Professor Chen's suggestion? If yes, explain why. Otherwise, give a counter example of $n = 4$ in which the optimal solution of the converted assignment problem is different from the shortest Hamiltonian cycle.

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2. [26%] In a reverse logistics network, there are four types of nodes: (1) collecting points (denoted by I) that collects recycled products, (2) storage site (denoted by S) that serves as a buffer where recycled products may be sorted or classified according to their conditions, (3) recycle plant (denoted by P) that disassemble and classify recyclied products, and (4) final treatment and landfill (denoted by R) which process the last stage of recycling. Suppose a reverse logistics company already have $|I|$ collecting points, $|S|$ storage sites, $|P|$ recycle plants, and $|R|$ final treatment and landfills. There are transportation lanes from nodes in I to nodes in S, from nodes in I to nodes in P, from nodes in S to nodes in P, and from nodes in P to nodes in R. This company earns money from the government by processing recycled products in each node in S and P and by selling some final products in S. However, it spends money for transporting products between nodes.

Suppose we are given the following parameters and variables:

- US : the capacity for each storage site in S
- UP : the capacity for each recycle plant in P
- c_{ij} : the unit transportation cost from node i to node j
- fS : the fixed cost to build a new storage site
- fP : the fixed cost to build a new recycle plant
- rS : the unit revenue supported by the government for each unit collected in a storage site in S
- rP : the unit revenue supported by the government for each unit processed in a recycle plant in P
- rR : the unit revenue earned in each final treatment and landfills in R
- A_i : the amount of recycled products collected in the ith collecting point in J
- $\widehat{S}$: the set of candidate storage sites
- $\widehat{P}$: the set of candidate recycle plants
- x_{ij} : the amount shipped from node i to node j in this reverse logistics network
- yS_i : a binary variable representing whether a new storage site i in $\widehat{S}$ is to be built (i.e. $yS_i = 1$) or not (i.e. $yS_i = 0$)
- yP_i : a binary variable representing whether a new recycle plant i in $\widehat{P}$ is to be built (i.e. $yP_i = 1$) or not (i.e. $yP_i = 0$)

Suppose this company is currently investigating facility location planning that plans to build new storage sites or recycle plants to achieve the maximum revenue. Answer the following questions:

(a) [5%] List all the decision variables for this facility location problem.

(b) [5%] Write the objective function. (hint: it contains two parts, revenues and costs)

(c) [5%] Write the flow balance constraints and capacity constraints associated with an old storage site $i \in S$.

(d) [6%] Write the capacity constraints associated with a new/candidate recycle plant $i \in P$.

(e) [5%] Suggest a method other than integer programming or linear programming to quickly give a good solution. Explain why your method works.

編號： 236 國立成功大學九十八學年度碩士班招生考試試題

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3. [16%] The Theory of Constraint (TOC) proposed by Eliyahu M. Goldratt has been widely discussed in the past. Answer the following questions.

   (a) [8%] Show the five-step TOC procedure associated with adequate explanations?

   (b) [8%] Use a conceptual schema to clearly explain the idea of Drum-Buffer-Rope (DBR). You need to provide adequate insights to get full credit.

4. [20%] Consider the jobs in the table below. Process times for all jobs are 1 hour. Changeovers between families require 4 hours. Thus, the completion time for job 1 is 5, for job 2 is 6, for job 3 is 11, and so on.

   (a) [6%] Compute the total tardiness of the sequence.

   (b) [6%] How many possible sequences are there?

   (c) [8%] Find a sequence with no tardiness.

Job	*Family Code*	*Due Date*
1	1	5
2	1	6
3	2	12
4	2	13
5	1	13
6	1	19
7	1	20
8	2	20
9	2	26
10	1	28

5. [14%] An activity relationship chart is shown below for the XY Mailbox Company. Given the space requirements (in square meter),

   (a) [7%] construct a relationship diagram for the manufacturing facility and

   (b) [7%] construct a block layout using Relationship Diagramming.