Applied Electronics

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Applied Electronics provides semiconductor chips for a variety of customers all over the world. The chips are produced at six fabrication plants and packaged into boxes of 100 chips.

The plants were originally designed to produce the quantity of chips required for the country where they were located, but as demand changes, there is the potential to produce chips in one country and ship them to another.

You have been asked to construct a model that will find an effcient production schedule for next year. This would set the production levels at each plant, and how many will be used locally and how many will be shipped to other regions.

Production Details

There are six plants around the world:

Mexico	Canada	Chile	Frankfurt	Austin	Japan

The original plant was in Japan so it has much higher costs than the newer plants. The second plant was built in the US (in Austin, Texas), then came the Frankfort plant (built to supply demand in Europe). The next plant was built in Chile to meet demand in Latin America. The last two plants were designed to meet local demand, a plant first in Canada, and then the newest plant in Mexico.

Each plant has designed capacity, but each plant should only be planned to produce around 80-90% of that capacity. Here are the plant capacities and how many chips are planned to be produced this year:

	Mexico	Canada	Chile	Frankfurt	Austin	Japan
Capacity (millions of chips)	22.0	3.7	4.5	47.0	18.5	5.0
Production Plan(millions of chips)	17.2	2.6	4.1	38.0	14.0	4.0

The demand in each area has changed over time due to competition and the customers who still use the chips that Applied Electronics produces:

	Mexico	Canada	Chile	Frankfurt	Austin	Japan
Demand (millions of chips)	3.0	2.6	16.0	20.0	26.4	11.9

The cost of supplying demand first consists of the production costs per box of 100 chips in that plant (all figures are converted to US dollars). These costs are a function of the plant design, but are also affected by local costs (labor, material, energy, for example).

	Mexico	Canada	Chile	Frankfurt	Austin	Japan
Production Cost (per box of 100)	92.63	93.25	112.31	73.34	89.15	149.24

Any boxes shipped to the region from a plant located in another region are subject to an import duty (a percentage of the cost).

	Mexico	Canada	Chile	Frankfurt	Austin	Japan
Import Duties (percent of cost)	60.0%	0.0%	50.0%	9.5%	4.5%	6.0%

For example, a box of chips produced in Canada and sent to Mexico would have an effective cost of $93.25 times 1.6, or $149.20.

Finally Applied Electronics has determined the additional shipping costs from one region to another (so the shipping cost within a region is zero). Here are the costs to ship a box from one region to another. These costs include air shipment rates and the costs of packaging to protect the boxes while in transit:

		To: Mexico	Canada	Chile	Frankfurt	Austin	Japan
From:	Mexico	–	11.40	7.00	11.00	11.00	14.00
	Canada	11.00	–	9.00	11.50	6.00	13.00
	Chile	7.00	10.00	–	13.00	10.40	14.30
	Frankfort	10.00	11.50	12.50	–	11.20	13.30
	Austin	10.00	6.00	11.00	10.00	–	12.50
	Japan	14.00	13.00	12.50	14.20	13.00	–

To be clear, boxes produced in Mexico cost $11.40 to ship to Canada, but boxes produced in Canada only cost $11.00 to ship to Mexico.

The objective is to create a plan that has the lowest total cost: production cost plus duties (if shipped to another region) plus shipping costs (if shipped to another region).

A team has created a production plan by trying to maximize the quantity that can be produced at each plant for local demand, in order to minimize duties and shipping. Then the team identified additional capacity from other plants to meet the total demand in the region. They have also tried to keep production quantities within reasonable bounds to allow for downtime and to keep some buffer capacity. Here is the plan:

	Mexico	Canada	Chile	Frankfurt	Austin	Japan	Total
Mexico	3.0	–	–	–	12.4	1.8	17.2
Canada	–	2.6	–	–	–	–	2.6
Chile	–	–	4.1	–	–	–	4.1
Frankfort	–	–	11.9	20.0	–	6.1	38.0
Austin	–	–	–	–	14.0	–	14.0
Japan	–	–	–	–	–	4.0	4.0

There is a spreadsheet with all of the data: `Applied Electronics Data.xlsx`. The total cost of the team's plan has been computed to be $78.445 million dollars. The team wonders if there is a good heuristic that could be used to create a better solution, and you suggest they utilize Vogel's approximation that we discussed in class.

Assignment

Important Restriction This assignment is a way for me to understand the programming skills of the class. You should not search the web for algorithms that implement VAM – this is not an assignment to see how good you are at searching for code. If you feel you are having difficulty with the algorithm, please contact me.

Please submit a short presentation deck that does the following.

1. Define a structure for the data that AE needs to provide to your algorithm. A text file (perhaps a .csv file) that is read by your algorithm is one way to do this (you do not need to try to interface with the spreadsheet provided). Or perhaps just identify part of your code where the user could copy-paste this particular situation, or new planning problems in the future.

2. Create code to implement Vogel's approximation method (VAM) that will find a good production plan for Applied Electronics. Describe the algorithm in the deck so the the planning team understands the logic of the heuristic and your implementation.

3. How much does this save versus the team's plan? You can use all of the capacity at each of the locations.

4. Since running production at 100% is not usually feasible, solve the production plan using at most 85% of the plant's capacity. How much more costly is this plan?

5. Since Chile is the plant that is the most difficult for Applied Electronics to support, create a plan that does not use Chile at all, but will continue to supply the demand for Latin America from the remaining plants (using at more 90% of the plant's capacity). How does the cost compare with the solution using production from Chile?