

Programming Competition Case



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Canadian Engineering Competition 2023
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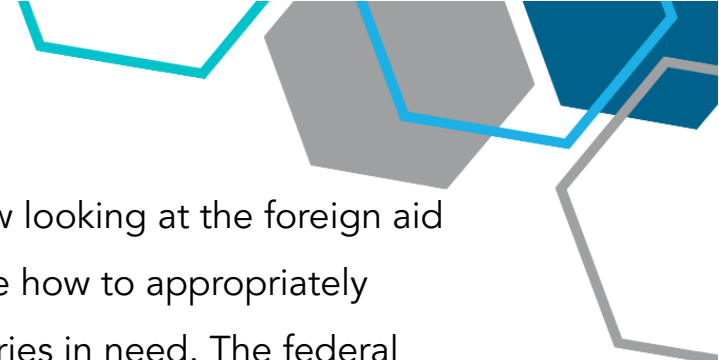
1. Background

Since the 1950s, Canada has been distributing cash, goods, and services to nations in need around the world [1]. After the Second World War, Canada joined the Colombo Plan to support recently independent Commonwealth countries of Asia and, in later decades, the Commonwealth Caribbean [1]. The distribution of this aid was managed by the Canadian International Development Agency (CIDA) before transitioning into the Department of Foreign Affairs, Trade and Development (DFATD) in 2013. [1].

In 2012, Canada's foreign aid spending was 0.31 percent of the country's GDP [1]. Some forms of aid in 2012 included wheat and flour, railway locomotives and parts, equipment for hydroelectric generation and transmission, fertilizer, and seeds and farm implements [1].



Figure 1: Emergency food kits being organized for families in regions of conflict [2].



The Canadian federal government is now looking at the foreign aid budget for 2023 and needs to determine how to appropriately allocate the available resources to countries in need. The federal government is undecided about what method to use to allocate these resources. In response, the DFATD has proposed five different methods of resource allocation. To compare the final impacts of using each method, the DFATD is now looking to create several visualizations comparing potential aid distributions.

2. Competition Challenge

The DFATD has contracted you, a group of engineers, to develop multiple software implementations that will visualize different proposed methods of resource allocation. The five proposed methods of resource allocation are the following:

1. As many countries as possible receive one requested resource in full
2. Each country receives an equal amount of resources by dollar amount
3. Resources are distributed proportionally according to Canada's target donations
4. Resources are distributed proportionally according to Canada's target donations (method 3) and based on an urgency metric
5. Resources are distributed on a weekly basis for four weeks (requiring multiple rounds of distribution). The resources will still be



divided proportionally according to Canada's target donations and based on an urgency metric (method 4)

A large data set including information regarding Canada's available resources for donation in 2023 is available and will be supplied, as shown in Table 1. A second large data set including information about Canada's targets for foreign aid in 2023 is also available and will be supplied, as shown in Table 2. A final large data set includes information regarding donation requests from different countries is available and will be supplied, as shown in Table 3. The provided data sets are in a .csv format, where each cell is represented by the headings shown in Table 1, Table 2, and Table 3.

Table 1: Canada's Available Resources - Data Format

Resource*	Sector*	Quantity	Unit	Total Value (\$CAD)
Resource1	String	Integer	String	Integer
...	String	Integer	String	Integer
ResourceN	String	Integer	String	Integer

Table 2: Canada's Target Donations for 2023 - Data Format

Country*	Target Donation Value (\$CAD)
Country1	Integer
...	Integer
CountryN	Integer



Table 3: Country Donation Requests - Data Format

Country	Resource *	Quantity	Unit	Sector *	Urgency	Time to Ship from Canada to Country (days)	Date Resource is Required By (yyyy-mm-dd)
Country1	String	Float	String	String	Decimal	Integer	String
...	String	Float	String	String	Decimal	Integer	String
Country N	String	Float	String	String	Decimal	Integer	String

Example Data

Refer to the following tables in the allocation methodology examples.

Table 1: Canada's Available Resources

Resource*	Sector*	Quantity	Unit	Total Value (\$CAD)
ResourceA	X	1	ton	500
ResourceB	X	5	L	500

Table 2: Canada's Target Donations for 2023

Country*	Target Donation Value (\$CAD)
CountryA	500
CountryB	100



Table 3: Country Donation Requests

Country	Resource*	Quantity	Unit	Sector *	Urgency	Time to Ship from Canada to Country (days)	Date Resource is Required By (yyyy-mm-dd)
CountryA	ResourceA	1.00	ton	X	0.8	6	2023-05-26
CountryA	ResourceB	3.00	L	X	0.2	5	2023-05-08
CountryB	ResourceA	1.00	ton	X	1.0	7	2023-05-08

It is important to note the primary keys of the tables. For Tables 1 and 3, the primary key is (Resource, Sector). For Table 2, the primary key is Country.

Resource allocation methodology 4 requires an urgency metric; this metric can be found in Table 3. This will be a decimal value between 0 and 1 (inclusive) that quantifies the factor by which a country's donation request in the various sectors and resources should be amplified. Each country's total urgency factor will sum up to 1 across the various sectors.

The developed software implementation should be able to read in these large data sets from the files and determine specific resources allocation for the five proposed scenarios. The team must then present this data in a visual format to help the DFATD determine how foreign aid will be distributed in 2023. Therefore, the designed



software implementations should be able to appropriately determine resource allocation for all proposed scenarios and the visualizations should clearly depict any relevant information that could help the DFATD understand the differences in resource allocation by methodology.

This software will prove to be an extremely valuable and important tool that the DFATD can use to help determine how foreign aid should be distributed in 2023. The department requires the code to be performant, efficient, and well documented as described in the design deliverables.

The goal of this assignment is to deliver the most resources by monetary value while following the underlying principles of each allocation methodology.

3. Specific Solution Objectives

This problem is divided into 3 stages:

1. Stage 1: Standardize the Data

1. Convert all data in Table 3 so that they are using the same units used in Table 1.

- i. It is recommended to use a library to perform these conversions such as Pint:

<https://pint.readthedocs.io/en/stable/user/defining-quantities.html> (however, any similar libraries are also permissible)



2. Stage 2: Allocate the Resources (one algorithm per allocation method).

Determine how to allocate resources by developing multiple algorithms that prioritize the following (based on the methods proposed in section 2):

- i. Allocation of 1 requested resource to as many countries as possible in full.
 1. Only Table 1 and Table 3 should be considered for this scenario.
 2. The following columns from Table 3 should not be considered: urgency metric, time to ship from Canada, and date required by.
 3. Countries may not receive any resources, but if they do, they must receive the full amount they requested

Example:

Input: Refer to page 5 for input data

Possible Allocation: {CountryA, 3, L, ResourceB, X}, {CountryB, 1, ton, ResourceA, X}

- ii. Allocate equally, where the aim is to equalize resources from a monetary standpoint.
 1. Only Table 1 and Table 3 should be considered for this scenario.



2. The following columns from Table 3 should not be considered: urgency metric, time to ship from Canada, and date required by.

Example:

Input: Refer to page 5 for input data

Possible Allocation: {CountryA, 3, L, ResourceB, X}, {CountryA, 0.2, ton, ResourceA, X}, {CountryB, 0.8, ton, ResourceA, X}

- iii. Allocate proportionally according to Canada's target donations, where the sum of their donation value is as close as possible to the target donation value.
 1. Table 1, Table 2, and Table 3 should be considered for this scenario.
 2. The following columns from Table 3 should not be considered: urgency metric, time to ship from Canada, and date required by.

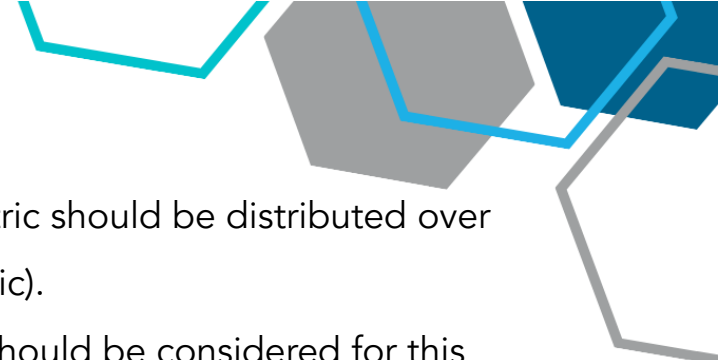
Example:

Input: Refer to page 5 for input data

Possible Allocation: {CountryA, 3, L, ResourceB, X}, {CountryA, 0.4, ton, ResourceA, X}, {CountryB, 0.2, ton, ResourceA, X}

- iv. Allocate according to urgency where resources should be given proportionally (according to Canada's target donations) and based on the urgency metric in Table 3. The goal of this allocation is to balance distributing proportionality with urgency (i.e.,





resources with a higher urgency metric should be distributed over resources with a lower urgency metric).

1. Table 1, Table 2, and Table 3 should be considered for this scenario.
2. The following columns from Table 3 should not be considered: time to ship from Canada, and date required by.

Example:

Input: Refer to page 5 for input data

Possible Allocation: {CountryA, 1, L, ResourceB, X}, {CountryA, 0.8, ton, ResourceA, X}, {CountryB, 0.2, ton, ResourceA, X}

- v. Allocation according to multiple rounds of distributions, once a week for four weeks, where target donations should be considered and dates when resources are required by should be taken into account. The four distribution rounds are May 1st, May 8th, May 15th, and May 22nd. All resources must arrive by the date specified in the column "Date Required By". The last date in the four-week period is May 29th. Each round of distribution can ship a maximum of 25% of the total Target Donation Value across all countries found in Table 2.

1. Table 1, Table 2, and Table 3 should be considered for this scenario.

Example:

Input: Refer to page 5 for input data



Possible Allocation:

Round 1 (May 1): {CountryB, 0.2, ton, ResourceA, X}, {CountryA, 0.5, L, ResourceB, X}

Round 2 (May 8): {CountryA, 0.3, ton, ResourceA, X}

Round 3 (May 15): {CountryA, 0.3, ton, ResourceA, X}

Round 4 (May 22):

Restrictions for Stage 2:

- You cannot allocate any more of a resource to a country than that country requested
- Canada is permitted to have leftover resources – all resources do not have to be distributed

3. Stage 3: Visualize the Results

1. Each algorithm developed in Stage 2 should include a visualization of how each resource was allocated. There should be one visualization for each of the following:
 - i. How much money each country received
 - ii. How many resources each country received per sector
 - iii. Which countries received each resource



Notes for Stage 3:

- There will be 15 visualizations total, 3 visualizations for each of the 5 resource allocation methods.
- You should consider using a library such as Matplotlib:
<https://matplotlib.org/>

4. Further Expectations/ Deliverables

You will have 8 hours to complete this competition. At the 8-hour mark, your team must provide all the outputs from the programs, your finalized code, and your group's presentation. Anything not in the folder before the deadline will not be considered as part of your submission.

Code Deliverable:

- All your code needs to be in the provided GitHub repositories Main branch before the 8-hour deadline in order for it to be considered.
- Basic instructions must be provided on how to compile and run your code.
 - o You must specify the language and version your code uses.
 - o You can assume that anyone who runs the code has the appropriate language installed.
 - o A list of required packages is advised (i.e., Pandas, NumPy).



Submission Files:

- stage2_1i.*
- stage2_1ii.*
- stage2_1iii.*
- stage2_1iv.*
- stage2_1v.*
- stage3.*
- stage3_visualizations.png
 - Includes 15 images with 3 images (Stage 3.i, 3.ii, 3.iii) per resource allocation method (Stage 2 i to v).

Where .* means any file extension.

Presentation Deliverable:

- Only presentations submitted in the provided GitHub repositories Main branch before the 8-hour deadline will be used in the presentation period. No work may be done on the presentation deliverable after the deadline has passed.
- You must discuss your group's implementation for each algorithm
- You must also discuss Stage 2 deliverables using visualizations done in Stage 3
- The presentation should review any and all results that could be collected from your team's program.
- You need to show some measure of CPU usage and memory (RAM) usage. This can be done by taking the time from start to



completion of the program, identifying the peak CPU load, and the peak RAM load that the program causes.

- o This can be done using a profiler such as vprof:

<https://github.com/nvdv/vprof> for Python programs or an equivalent profiler for other languages

5. Judging Metrics

Programming Judging Matrix		
Strategy/Algorithm	Simplicity	/10
	Ingenuity	/10
	Ability to Achieve Desired Outcome	/15
		/35
Code	Structure	/10
	Consistency	/5
	Readability	/10
	Efficiency	/10
		/35
Resource Management	Memory Usage Efficiency	/5
	Program's CPU Usage	/5
		/10
Presentation	Design Process and Justification	/7
	Design Critique	/4
	Voice, Articulation and Timing	/4
	Visual Aids	/2
	Response to Questions	/3
		/20
Deduction Total		
Total		/100

Figure 4: Programming Judges Rubric.



The judges will be using the matrix shown above in Figure 4 to determine how well your team meets expectations.

The judging metrics, and all competition rules can be found in the CEC 2023 Rule Book.

Please be aware that there are certain actions that can cause your team to incur penalties, therefore you should be familiar with the penalty matrix in Figure 5.

Programming Point Penalties	
Plagiarism	Elimination
Documents Received After Deadline	-50
Absent Team Member	-25
Entering presentation room before allotted time (after first offense)	-10
Total	

Figure 5: Programming Penalty Rubric.

6. Definitions

Primary Key: the columns that identify the unique rows in a table.

Urgency Metric: A decimal value between 0 and 1 (inclusive) that quantifies the factor by which a country's donation request in the various sectors should be amplified. Each country's total urgency metric will sum up to 1 across the various sectors.



7. References

- [1] <https://www.thecanadianencyclopedia.ca/en/article/foreign-aid>
- [2] <https://canadianaviationnews.wordpress.com/2022/04/26/air-canada-airlink-flexport-org-and-globalmedic-send-aid-and-medical-supplies-to-support-ukrainian-refugees-on-second-special-humanitarian-flight/>

