**Different thresholds**

-description: we want to know how different aspects of our definition of models for state quality calculation will influence the solutions we find in our simulation. A very important aspect of our models is how we define thresholds for different types of resources. When we are assigning resource amounts of each resource for different countries, we use the Random function in excel that generates an integer in the range of [0, 10]. We multiply this number with a value n, which can be different for different resources, and add to a minimum value, which can also be different for different resources. So the resource amount that can be generated for a resource to a country is in the range of [min, min+10n]. Our definition of thresholds are also using this way of definition. Originally, the 1st threshold for materials is min + n, the 2nd threshold for materials is min + 4n, and the threshold for waste is min + 5n. We think it is worth experimenting how the results may change if we change these thresholds. For example, we can change the 1st threshold to min + 2n and see how it influences the results.

-initial state:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Country | population | metalElements | timber | landArea | water | metalAlloys | electronics | housing | food | metalAlloysWaste | housingWaste | electronicsWaste | foodWaste |
| Atlantis | 11000 | 1900 | 19000 | 10000 | 50000 | 700 | 1400 | 13000 | 21000 | 1100 | 1200 | 1300 | 1500 |
| Brobdingnag | 11000 | 1900 | 19000 | 15000 | 37500 | 1100 | 500 | 12000 | 20000 | 1900 | 2000 | 1100 | 1500 |
| Carpania | 13000 | 2000 | 7000 | 30000 | 52500 | 700 | 700 | 20000 | 19000 | 1600 | 1500 | 1800 | 1300 |
| Dinotopia | 11000 | 1200 | 17000 | 35000 | 37500 | 900 | 1200 | 21000 | 17000 | 1100 | 1600 | 1700 | 1500 |
| Erewhon | 11000 | 2000 | 15000 | 20000 | 50000 | 1400 | 1300 | 20000 | 18000 | 1600 | 1500 | 2000 | 1600 |
| MyCountry | 13000 | 1800 | 13000 | 30000 | 40000 | 800 | 900 | 16000 | 19000 | 1700 | 1800 | 1800 | 1300 |

Test 1

-description:

In this test, the input resources file contains the original thresholds for materials and wastes. Specifically, it is min + n for materials’ 1st threshold, min + 4n for materials’ 2nd threshold, and min + 5n for wastes’ threshold.

-parameters:

initial\_state\_filename = "./input\_files/countries\_threshold.xlsx"

initial\_resources\_filename = "./input\_files/Resources\_Different\_Threshold original.xlsx"

output\_schedule\_filename = "./output\_files/change\_threshold original.txt"

depth = 4

solution\_limit = 100000

-output:

Number of solutions: 1

Best solution EU: 494686

Best Path:

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 494686')

Number of solutions: 5

Best solution EU: 709286

Best Path:

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 494686')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 709286')

Number of solutions: 10

Best solution EU: 709286

Best Path:

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 494686')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 709286')

Number of solutions: 50

Best solution EU: 709286

Best Path:

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 494686')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 709286')

Number of solutions: 100

Best solution EU: 709286

Best Path:

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 494686')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 709286')

Number of solutions: 500

Best solution EU: 709286

Best Path:

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 494686')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 709286')

Number of solutions: 1000

Best solution EU: 709286

Best Path:

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 494686')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 709286')

Number of solutions: 100000

Best solution EU: 709286

Best Path:

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 494686')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 709286')

Test 2

-description:

In this test, the input resources file contains the changed 1st thresholds for materials, the same 2nd threshold for materials and same threshold for wastes, compared with the original thresholds. Specifically, it is min + 2n for materials’ 1st threshold, min + 4n for materials’ 2nd threshold, and min + 5n for wastes’ threshold.

-parameters:

initial\_state\_filename = "./input\_files/countries\_threshold.xlsx"

initial\_resources\_filename = "./input\_files/Resources\_Different\_Threshold 1st.xlsx"

output\_schedule\_filename = "./output\_files/change\_threshold 1st.txt"

depth = 4

solution\_limit = 100000

-output:

Number of solutions: 1

Best solution EU: 494686

Best Path:

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 494686')

Number of solutions: 5

Best solution EU: 709286

Best Path:

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 494686')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 709286')

Number of solutions: 10

Best solution EU: 709286

Best Path:

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 494686')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 709286')

Number of solutions: 50

Best solution EU: 709286

Best Path:

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 494686')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 709286')

Number of solutions: 100

Best solution EU: 709286

Best Path:

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 494686')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 709286')

Number of solutions: 500

Best solution EU: 709286

Best Path:

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 494686')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 709286')

Number of solutions: 1000

Best solution EU: 709286

Best Path:

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 494686')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 709286')

Number of solutions: 100000

Best solution EU: 709286

Best Path:

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 494686')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 709286')

Test 3

-description:

In this test, the input resources file contains the changed 2nd thresholds for materials, the same 1st threshold for materials and same threshold for wastes, compared with the original thresholds. Specifically, it is min + n for materials’ 1st threshold, min + 8n for materials’ 2nd threshold, and min + 5n for wastes’ threshold.

-parameters:

initial\_state\_filename = "./input\_files/countries\_threshold.xlsx"

initial\_resources\_filename = "./input\_files/Resources\_Different\_Threshold 2nd.xlsx"

output\_schedule\_filename = "./output\_files/change\_threshold 2nd.txt"

depth = 4

solution\_limit = 100000

-output:

Number of solutions: 1

Best solution EU: 494686

Best Path:

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 494686')

Number of solutions: 5

Best solution EU: 1316548

Best Path:

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 494686')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 890252')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 1201388')

('TRANSFER', 'Brobdingnag', 'MyCountry', ('electronics', 100), 'EU: 1316548')

('TRANSFER', 'MyCountry', 'Brobdingnag', ('food', 2388.8888888888887), 'EU: 1316548')

Number of solutions: 10

Best solution EU: 1316548

Best Path:

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 494686')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 890252')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 1201388')

('TRANSFER', 'Dinotopia', 'MyCountry', ('electronics', 100), 'EU: 1316548')

('TRANSFER', 'MyCountry', 'Dinotopia', ('food', 2388.8888888888887), 'EU: 1316548')

Number of solutions: 50

Best solution EU: 1316548

Best Path:

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 494686')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 890252')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 1201388')

('TRANSFER', 'Erewhon', 'MyCountry', ('electronics', 100), 'EU: 1316548')

('TRANSFER', 'MyCountry', 'Erewhon', ('food', 2388.8888888888887), 'EU: 1316548')

Number of solutions: 100

Best solution EU: 1316548

Best Path:

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 494686')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 890252')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 1201388')

('TRANSFER', 'Brobdingnag', 'MyCountry', ('electronics', 100), 'EU: 1316548')

('TRANSFER', 'MyCountry', 'Brobdingnag', ('food', 2388.8888888888887), 'EU: 1316548')

Number of solutions: 500

Best solution EU: 1316548

Best Path:

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 494686')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 890252')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 1201388')

('TRANSFER', 'Erewhon', 'MyCountry', ('electronics', 100), 'EU: 1316548')

('TRANSFER', 'MyCountry', 'Erewhon', ('food', 2388.8888888888887), 'EU: 1316548')

Number of solutions: 1000

Best solution EU: 1316548

Best Path:

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 494686')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 890252')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 1201388')

('TRANSFER', 'Brobdingnag', 'MyCountry', ('electronics', 100), 'EU: 1316548')

('TRANSFER', 'MyCountry', 'Brobdingnag', ('food', 2388.8888888888887), 'EU: 1316548')

Number of solutions: 100000

Best solution EU: 1316548

Best Path:

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 494686')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 890252')

('TRANSFER', 'Brobdingnag', 'MyCountry', ('electronics', 100), 'EU: 1062670')

('TRANSFER', 'MyCountry', 'Brobdingnag', ('food', 2388.8888888888887), 'EU: 1062670')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 1316548')

Test 4

-description:

In this test, the input resources file contains the changed 1st and 2nd thresholds for materials and the same threshold for wastes, compared with the original thresholds. Specifically, it is min + 2n for materials’ 1st threshold, min + 8n for materials’ 2nd threshold, and min + 5n for wastes’ threshold.

-parameters:

initial\_state\_filename = "./input\_files/countries\_threshold.xlsx"

initial\_resources\_filename = "./input\_files/Resources\_Different\_Threshold 1st+2nd.xlsx"

output\_schedule\_filename = "./output\_files/change\_threshold 1st+2nd.txt"

depth = 4

solution\_limit = 100000

-output:

Number of solutions: 1

Best solution EU: 494686

Best Path:

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 494686')

Number of solutions: 5

Best solution EU: 1316548

Best Path:

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 494686')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 890252')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 1201388')

('TRANSFER', 'Brobdingnag', 'MyCountry', ('electronics', 100), 'EU: 1316548')

('TRANSFER', 'MyCountry', 'Brobdingnag', ('food', 2388.8888888888887), 'EU: 1316548')

Number of solutions: 10

Best solution EU: 1316548

Best Path:

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 494686')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 890252')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 1201388')

('TRANSFER', 'Dinotopia', 'MyCountry', ('electronics', 100), 'EU: 1316548')

('TRANSFER', 'MyCountry', 'Dinotopia', ('food', 2388.8888888888887), 'EU: 1316548')

Number of solutions: 50

Best solution EU: 1316548

Best Path:

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 494686')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 890252')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 1201388')

('TRANSFER', 'Erewhon', 'MyCountry', ('electronics', 100), 'EU: 1316548')

('TRANSFER', 'MyCountry', 'Erewhon', ('food', 2388.8888888888887), 'EU: 1316548')

Number of solutions: 100

Best solution EU: 1316548

Best Path:

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 494686')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 890252')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 1201388')

('TRANSFER', 'Brobdingnag', 'MyCountry', ('electronics', 100), 'EU: 1316548')

('TRANSFER', 'MyCountry', 'Brobdingnag', ('food', 2388.8888888888887), 'EU: 1316548')

Number of solutions: 500

Best solution EU: 1316548

Best Path:

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 494686')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 890252')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 1201388')

('TRANSFER', 'Erewhon', 'MyCountry', ('electronics', 100), 'EU: 1316548')

('TRANSFER', 'MyCountry', 'Erewhon', ('food', 2388.8888888888887), 'EU: 1316548')

Number of solutions: 1000

Best solution EU: 1316548

Best Path:

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 494686')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 890252')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 1201388')

('TRANSFER', 'Brobdingnag', 'MyCountry', ('electronics', 100), 'EU: 1316548')

('TRANSFER', 'MyCountry', 'Brobdingnag', ('food', 2388.8888888888887), 'EU: 1316548')

Number of solutions: 100000

Best solution EU: 1316548

Best Path:

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 494686')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 890252')

('TRANSFER', 'Dinotopia', 'MyCountry', ('electronics', 100), 'EU: 1062670')

('TRANSFER', 'MyCountry', 'Dinotopia', ('food', 2388.8888888888887), 'EU: 1062670')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 1316548')

Test 5

-description:

In this test, the input resources file contains the same 1st and 2nd thresholds for materials and the changed threshold for wastes, compared with the original thresholds. Specifically, it is min + n for materials’ 1st threshold, min + 4n for materials’ 2nd threshold, and min + 7.5n for wastes’ threshold.

-parameters:

initial\_state\_filename = "./input\_files/countries\_threshold.xlsx"

initial\_resources\_filename = "./input\_files/Resources\_Different\_Threshold waste.xlsx"

output\_schedule\_filename = "./output\_files/change\_threshold waste.txt"

depth = 4

solution\_limit = 100000

-output:

Number of solutions: 1

Best solution EU: 494686

Best Path:

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 494686')

Number of solutions: 5

Best solution EU: 709286

Best Path:

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 494686')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 709286')

Number of solutions: 10

Best solution EU: 709286

Best Path:

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 494686')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 709286')

Number of solutions: 50

Best solution EU: 709286

Best Path:

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 494686')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 709286')

Number of solutions: 100

Best solution EU: 709286

Best Path:

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 494686')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 709286')

Number of solutions: 500

Best solution EU: 709286

Best Path:

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 494686')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 709286')

Number of solutions: 1000

Best solution EU: 709286

Best Path:

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 494686')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 709286')

Number of solutions: 100000

Best solution EU: 709286

Best Path:

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 494686')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 709286')

Test 6

-description:

In this test, the input resources file contains the changed 1st and 2nd thresholds for materials and the changed threshold for wastes, compared with the original thresholds. Specifically, it is min + 2n for materials’ 1st threshold, min + 8n for materials’ 2nd threshold, and min + 7.5n for wastes’ threshold.

-parameters:

initial\_state\_filename = "./input\_files/countries\_threshold.xlsx"

initial\_resources\_filename = "./input\_files/Resources\_Different\_Threshold 1st+2nd +waste.xlsx"

output\_schedule\_filename = "./output\_files/change\_threshold 1st+2nd +waste.txt"

depth = 4

solution\_limit = 100000

-output:

Number of solutions: 1

Best solution EU: 494686

Best Path:

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 494686')

Number of solutions: 5

Best solution EU: 1316548

Best Path:

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 494686')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 890252')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 1201388')

('TRANSFER', 'Brobdingnag', 'MyCountry', ('electronics', 100), 'EU: 1316548')

('TRANSFER', 'MyCountry', 'Brobdingnag', ('food', 2388.8888888888887), 'EU: 1316548')

Number of solutions: 10

Best solution EU: 1316548

Best Path:

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 494686')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 890252')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 1201388')

('TRANSFER', 'Dinotopia', 'MyCountry', ('electronics', 100), 'EU: 1316548')

('TRANSFER', 'MyCountry', 'Dinotopia', ('food', 2388.8888888888887), 'EU: 1316548')

Number of solutions: 50

Best solution EU: 1316548

Best Path:

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 494686')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 890252')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 1201388')

('TRANSFER', 'Erewhon', 'MyCountry', ('electronics', 100), 'EU: 1316548')

('TRANSFER', 'MyCountry', 'Erewhon', ('food', 2388.8888888888887), 'EU: 1316548')

Number of solutions: 100

Best solution EU: 1316548

Best Path:

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 494686')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 890252')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 1201388')

('TRANSFER', 'Brobdingnag', 'MyCountry', ('electronics', 100), 'EU: 1316548')

('TRANSFER', 'MyCountry', 'Brobdingnag', ('food', 2388.8888888888887), 'EU: 1316548')

Number of solutions: 500

Best solution EU: 1316548

Best Path:

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 494686')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 890252')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 1201388')

('TRANSFER', 'Erewhon', 'MyCountry', ('electronics', 100), 'EU: 1316548')

('TRANSFER', 'MyCountry', 'Erewhon', ('food', 2388.8888888888887), 'EU: 1316548')

Number of solutions: 1000

Best solution EU: 1316548

Best Path:

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 494686')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 890252')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 1201388')

('TRANSFER', 'Brobdingnag', 'MyCountry', ('electronics', 100), 'EU: 1316548')

('TRANSFER', 'MyCountry', 'Brobdingnag', ('food', 2388.8888888888887), 'EU: 1316548')

Number of solutions: 100000

Best solution EU: 1316548

Best Path:

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 494686')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 890252')

('TRANSFER', 'Dinotopia', 'MyCountry', ('electronics', 100), 'EU: 1062670')

('TRANSFER', 'MyCountry', 'Dinotopia', ('food', 2388.8888888888887), 'EU: 1062670')

('TRANSFORM', 'MyCountry', (('population', 192), ('metalElements', 128), ('metalAlloys', 128)), (('population', 192), ('electronics', 128), ('electronicsWaste', 128)), 'EU: 1316548')

Test Cases Result Explanation:

Comparing the generated results of the 6 tests, we can see that the expected utilities of the best solutions in Test 1 (original thresholds: 1st for materials being min + n, 2nd for materials being min + 4n, the threshold for waste being min + 5n), Test 2 (only change 1st threshold for materials, 1st for materials being min + 2n, 2nd for materials being min + 4n, the threshold for waste being min + 5n), Test 5 (only change threshold for wastes: 1st for materials being min + n, 2nd for materials being min + 4n, the threshold for waste being min + 7.5n) are all same (around 700000). We can also see that the expected utilities of the best solutions in Test 3 (only change 2nd thresholds: 1st for materials being min + n, 2nd for materials being min + 8n, the threshold for waste being min + 5n), Test 4 (change 1st and 2nd thresholds for materials, 1st for materials being min + 2n, 2nd for materials being min + 8n, the threshold for waste being min + 5n), Test 5 (only all thresholds: 1st for materials being min + 2n, 2nd for materials being min + 8n, the threshold for waste being min + 7.5n) are all same (around 1300000). This tells us that only our changes in 2nd threshold influence the decision that MyCountry does in its searches for successor states. When we look closely at the generated schedules, we can find that for Test 1, 2, and 5, the best schedule for MyCountry is doing 2 transforms of 128 electronics. But for Test 3, 4, and 6, the best schedule for MyCountry is doing 2 transforms of 128 electronics, then doing one trade that transfers some food for the other country’s electronics, and doing another transform of 128 electronics. The reason behind this difference can be because of the initial resource amount of each resources for MyCountry. If we check the initial state of MyCountry, we can see that all of its resources have amount equal to or larger than min + 3n, which is even larger than our changed 1st threshold. Since the first threshold is the survival threshold, this indicates that MyCountry is in a relatively resource-rich state, so it will not eagerly search for operators that can increase its most demanded resources for survival. This is also the reason for why we do not see solutions change when we change the 1st threshold for materials. According to our models, the materials are usually most encouraged to be traded to other countries when their amount is between 1st and 2nd thresholds because the market is saturated after the 2nd threshold. Because most of the resources for MyCountry are between min + 4n and min + 8n, the resources for MyCountry are mostly above original 2nd threshold (min + 4n). This makes MyCountry more inclined to do transform instead of transfer. And since electronics’ resource amount is low but weight is high, it can give the most increase in state quality among all possible transforms for MyCountry. So MyCountry would like to do 2 transforms of electronics for Test 1, 2, and 5 when the 2nd threshold for materials is only min + 4n. But when we change it to min + 8n in Test 3, 4, and 6, a lot of the resources for MyCountry are then between 1st and 2nd thresholds. This makes MyCountry more inclined to do trades, and since electronics’ amount is still relatively smaller but can bring large increase in state quality for MyCountry, MyCountry are inclined to trade its other resources for another country’s electronics. The reason behind no change in wastes can be because the weights and amounts for wastes are low, so they do not play very important roles in any types of operations in our defined world. So even if we make big changes to the thresholds, no change is made in solutions.