Criterion C - Development

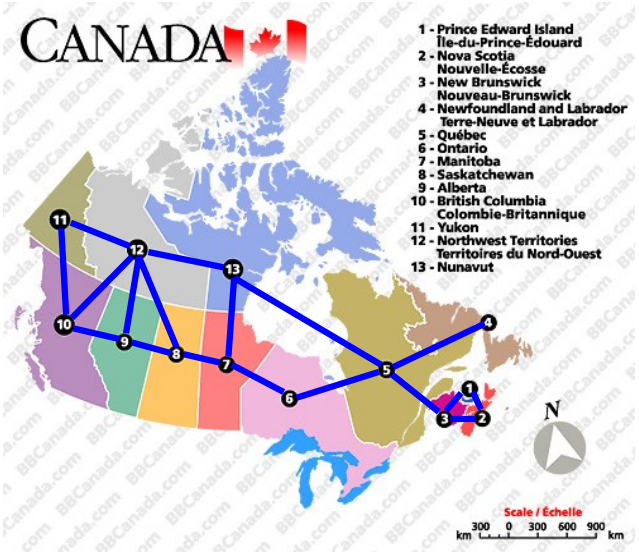
The product is a Python program. It accepts map data about bordering regions from a text-file written by the user. It automatically searches for a set of acceptable colors for the regions, using at most 4 colors, so that bordering countries never share the same color.

-List of techniques –

- Parameter passing
- Random number generating
- Indexing from one list to another
  [techniques clearly listed]

- Map Diagrams -

Computer scientists define a data-structure called a "map diagram". This records only the **connections** between regions, without recording long borders and large regions. This turns complex regions into simple connecting lines, like these blue lines:



Source: BBCanada http://www.bbcanada.com/bb_canada_map.cfm accessed 18 Feb 2011
'Maps courtesy of BBCanada.com, www.BBCanada.com '

Each line connects two neighboring regions. Notice that 4 regions in the middle meet at one point , but diagonal neighbors are NOT connected - e.g. #8 and #13 may have the same color. Each region only needs a list of neighbors, and that list is only as long as the number of line segments connecting to that region, like this:

```
YU --> BC,NW BC
--> YU,NW,AL
NW --> YU,NU,BC,AL,SA
```

```
 AL --> BC,NW,SA
SA  -->  AL,NW,MA
NU  -->  NW,MA,QU
MA --> SA,NU,ON
ON --> MA,QU
QU --> ON,NU,NF,NB
NF --> QU
NB --> QU,NS,PE
NS --> NB,PE PE
--> NB,NS
```

This requires minimal data entry. **[explanation for use of text file]** It's also easy because each entry only requires looking at a small part of the map, examining just the neighbors around a region. The order of the entries doesn't matter, so changes are easy. We"d like to just put a paper map into a scanner and let the computer figure out the borders - but that requires image-recognition and AI techniques well beyond my programming skills.

Clear explanation of technique used.

- Input/Output -

The user types the border data with a text editor (e.g. Notepad) and saves it in a text-file.
This data is for the Canada map (above). The first entry in each line specifies a region, while the further entries in the line are the neighbors of that region.
The program reads this file and stores the data in a convenient format in a **dictionary**.
→ *See code for the* **readBorders** *method.*
[evidence of code in the form of an annotated screenshot would be helpful]

When a set of acceptable colors is found, the regions and matching colors are printed in a simple list as shown at the right.
→ *See code for the* **listColors** *method.*
[as above]

Canada text-file

```
YU,BC,NW BC,YU,NW,AL
NW,YU,NU,BC,AL,SA
AL,BC,NW,SA
SA,AL,NW,MA
NU,NW,MA,QU
MA,SA,NU,ON ON,MA,QU
QU,ON,NU,NF,NB NF,QU
NB,QU,NS,PE
NS,NB,PE
PE,NB,NS
```

Sample Output

```
Map name (e.g. CANADA)?canada
=== Map =  canada  ===
YU  :  ['BC', 'NW']
BC  :  ['YU', 'NW', 'AL']
NW  :  ['YU', 'NU', 'BC', 'AL', 'SA']
AL  :  ['BC', 'NW', 'SA']
SA  :  ['AL', 'NW', 'MA']
NU  :  ['NW', 'MA', 'QU']
MA  :  ['SA', 'NU', 'ON']
ON  :  ['MA', 'QU']
QU  :  ['ON', 'NU', 'NF', 'NB']
NF  :  ['QU']
NB  :  ['QU', 'NS', 'PE']
NS  :  ['NB', 'PE']
PE  :  ['NB', 'NS']
==================
ON  =  red
MA  =  green
BC  =  yellow
NB  =  yellow
AL  =  red
NF  =  yellow
PE  =  blue
QU  =  blue
SA  =  yellow
NS  =  green
YU  =  blue
NU  =  red
NW  =  green
```

- Algorithms to Search for a Color Scheme -

There are two possible strategies for searching for creating the map using the acceptable colors:

1. Search for an algorithm that always produces a successful coloring scheme

- OR -

2. assign colors randomly and check whether the set of colors is acceptable (neighbors don't have the same color) - if the colors don't work, then repeat with a different random set, until a successful set is found (or quit after 1000 tries)

I was unable to find a straightforward algorithm that works for every map, therefore the solution I developed uses a random guess and check strategy. → *See code for the* **randomColors** *method.*

```
def randomColors(choices):     # choose a random color for each region
    for n in range(0,max):
        c = random.randint(0,choices-1)  # random number
        co[n] = colors[c]                # store random color in colors list
```

The program tries 1000 times to find a successful color scheme (it may be necessary to re-run another 1000, several times, to succeed with a difficult map). For each color scheme, it must check whether the colors are acceptable. → *See source code for the* **checkColors** *method.*
[evidence of code in the form of an annotated screenshot would be helpful]

There is a clear explanation as to why the student has chosen the technique.
It would be useful if there was evidence of research into map colouring algorithms within this criterion.

- Algorithm Overview -

- The program will provide automated searching for acceptable color combinations

Algorithm	Purpose	Comments
Input Border Data (#1)	read text-file (created by client) and input border	
Randomly Choose Colors (#2)	choose a random color for each country	this must be automated, no user input
Check Correctness of Colors (#3)	check the colors assigned against all pairs of neighboring countries	reject color set if one conflict is found
Repeat Search (#4)	Repeat until success or failure	

#1 - Inputting Borders Data from a File -

```
pseudocode for LoadingBordersData

   COUNT = 0

   Borders = empty list

   open data file
   repeat until end of file

       info = readLine   (e.g.  BC,YU,NW,AL)

       split info into array of Strings --> data[]

 append data[] to the Borders array
```

#2 - Generating Sets of Colors - This could be written using the pseudo code developed by Colin and Lise

```
pseudocode for RandomColors

    Colors = empty list

    for each REGION in the Borders list

        select a random COLOR 1..4 (or 1..3 if max-colors is 3)

  record the name of the REGION and the COLOR in the Colors list
```

#3 - Detecting Incorrect Colors -

```
pseudocode for Checking

   SUCCESS = True
```

```
    for each REGION in the Borders list

        for each NEIGHBOR of the REGION

            look up REGION.COLOR in the Colors list
            look up NEIGHBOR.COLOR in the Colors list

            if REGION.COLOR == NEIGHBOR.COLOR

                SUCCESS = False

    return SUCCESS
```

#4 – Repeat search -

Show how program shows whether search has been successful or not.

- Data Structures -

The program uses several types of lists:

- **tuples** - standard names of 4 colors are stored in a tuple (which never changes): `colors = ("red","green","blue","yellow")`
- **arrays -** the list of randomly chosen colors is stored in an array, indexed by integers :

```
def  randomColors()  :
    for  nin  range(0,max)  :
        c =  random.randint(0,choices-1)
        co[n]  =  colors[c]
```

- **dictionaries**

  - the **borders** data is stored in a dictionary :

```
border  =  {"YU":["BC","NW"],
           "BC":["YU","NW","AL"],
           "NW":["YU","NU","BC","AL","SA"],
            .....
          }
```

  This makes it easy to store the neighbors together with a region, as well as making it easy to retrieve data by name (no search method required). **[Explanation has been given in input/output section]**

  - the **state** dictionary contains each country code and a corresponding number:

```
state  =  {"YU":0,
           "BC":1,
           "NW":2,
            ...
          }
```

  The purpose of the **state** dictionary is to convert a country code into an index number that is used to get the matching color in the color array. This is more convenient than a search method.
  [This information requires the moderator to look at the source code in detail to gather an understanding of the state dictionary approach and then imagine what sort of a search

method the student might be referring to before determining why the state dictionary is better than the search method. A better strategy would be to present the alternative in sufficient detail that the advantages of the selected approach can be appreciated]

These lists are used to combine color assignments and border data in the checkingColors method - → *see source code for the* **checkColors** *method.*

The elements required to support the functionality are not specified.
There is no explanation as to why these data structures have been chosen or what alternatives were considered.

- Program Code Listing -

The program is written with good style and reusable methods with parameters and return values, improving readability and maintainability. The **dicitionary** structure and convenient Python commands like **slice** make the program relatively short.

** Words = 300 **

There is clear evidence of the use of techniques which demonstrates a high level of complexity and ingenuity in addressing the scenario identified in criterion A.

It is characterised by the appropriate use of existing tools.

The techniques are adequate for the task, however their use is not fully explained and the absence of screenshots would require the moderator to search the code in the appendix.

Sources such as the map of Canada on page 1 were not identified. The code was generated by the student.

This criterion was awarded 9 marks using best fit and benefit of doubt. It was felt that there were some minor gaps in the explanations such as relating to tuples and the borders dictionary. Additionally the student failed to cite the source of the map which was relevant to explaining the data structures.