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How to Run Program

1) Compile and run. Type the following into the terminal:

```
g++ routing.cpp -o routing
./routing
```

2) What the results mean (results are printed in the terminal when program is run)
   a. First table is a table from specified node to <u>all other nodes</u> (documented in the map_of_canada.txt file) using Dijkstra's link-state routing algorithm.

```
<< TABLE OF LEAST-COST-PATH TO ALL OTHER NODES >>
Destination     Cost    Hops    Shortest Path
YEG             157     1       YYC -> YEG
YQR             440     1       YYC -> YQR
YXE             365     1       YYC -> YXE
YVR             720     1       YYC -> YVR
YWG             802     2       YYC -> YQR -> YWG
YUL             2410    4       YYC -> YQR -> YWG -> YYZ -> YUL
YYZ             2097    3       YYC -> YQR -> YWG -> YYZ
YYJ             871     2       YYC -> YVR -> YYJ
YOW             2188    3       YYC -> YQR -> YWG -> YOW
YQB             2578    5       YYC -> YQR -> YWG -> YYZ -> YUL -> YQB
YHZ             3105    4       YYC -> YQR -> YWG -> YYZ -> YHZ
YQM             3238    5       YYC -> YQR -> YWG -> YYZ -> YHZ -> YQM
YFC             3331    5       YYC -> YQR -> YWG -> YYZ -> YHZ -> YFC
YQX             4560    6       YYC -> YQR -> YWG -> YYZ -> YHZ -> YFC -> YQX
YYT             4330    5       YYC -> YQR -> YWG -> YYZ -> YUL -> YYT
YXY             1454    2       YYC -> YEG -> YXY
YZF             1061    2       YYC -> YEG -> YZF
YFB             1837    2       YYC -> YEG -> YFB
YXX             666     1       YYC -> YXX
YXS             514     1       YYC -> YXS
```

Figure 1. table of Canadian routing results

   b. Second table is a summary from the table above from YYC to <u>other nodes in Canada specified in the traceroute</u> results below using Dijkstra's link-state routing algorithm.

```
<< RESULTS SUMMARY >>
Destination     Cost    Hops    Shortest Path
Vancouver       720     1       YYC -> YVR
Toronto         2097    3       YYC -> YQR -> YWG -> YYZ
Winnipeg        802     2       YYC -> YQR -> YWG
```

Figure 2. tabular summary

Traceroute Results

Category	Destination	DomainName	IP Address	Location (actual)	When(UC)	NumHops	BaseRTT (ms)	When(Home)	NumHops	BaseRTT
AB1	Edmonton, Alberta	edmonton.ca	35.190.75.248	Mountain View, California	2021-11-15 13:42	16	25	2021-11-15 19:58	7	28
CAN1	Vancouver, British Columbia	vancouver.ca	199.175.219.1	Vancouver, British Columbia	2021-11-15 13:44	16	40	2021-11-15 19:59	10	25
CAN2	Toronto, Ontario	utoronto.ca	128.100.166.120	Toronto, Ontario	2021-11-15 13:47	21	50	2021-11-15 20:01	13	70
CAN3	Winnipeg, Manitoba	uwinnipeg.ca	72.2.13.34	Winnipeg, Manitoba	2021-11-15 13:50	15	23	2021-11-15 20:03	11	87
US1	Seattle, Washington	spaceneedle.com	104.248.51.102	North Bergen, New Jersey	2021-11-15 13:52	18	68	2021-11-15 20:05	9	59
US2	Hollywood, California	universalstudioshollywood.com	184.50.210.219	New York, New York	2021-11-15 13:55	17	57	2021-11-15 20:07	8	78
INTL1	Cambridge, UK	cam.ac.uk	128.232.132.8	Cambridge, UK	2021-11-15 13:58	24	137	2021-11-15 20:09	16	147
INTL2	Bangkok, Thailand	chula.ac.th	45.60.124.77	Redwood City, California	2021-11-15 14:00	18	177	2021-11-15 20:11	7	45

Table 1. Traceroute Results [1][2]

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Written Summary

Observing the traceroute results (Table 1) above we can see that RTT can vary, most were similar between home and the university, except the very last row in the table with over 100ms difference. Generally, when pinging a website from my home network it took less hops than when at the university, when looking at the IPs of the hops it is evident that it is because the route from the university must go through a lot of different routers before it leaves the school AS and canarie AS (both have many routers inside their autonomous system). The route from the university's network to canarie's network is an example of policy-based routing.

When comparing the traceroute results (Table 1) to the results using Dijkstra's algorithm (Figure 2), you can see that the one-way trip time of the algorithm is much greater than the round-trip-time found in actual real world results (traceroute). And when you compare the number of hops the algorithm has way less hops than the number of hops found in real world routes. Since there are many possible paths to route to a certain destination server with many different possible routers, the paths from traceroute verses the paths calculated by the algorithm are very different.

The most interesting actual locations was the website of a school in Thailand. Although it is on the other side of the world, its website is hosted on a server located in California.

References

[1] "Free IP Geolocation API and Accurate IP Geolocation Database." *IPGeolocation API*, https://ipgeolocation.io/. (*Accessed: 15 November 2021*)

[2] "Online NSLOOKUP - Find DNS Records." *Online Nslookup - Find DNS Records*, https://www.nslookup.io/. (*Accessed: 15 November 2021*)