TenX Technical Exercise

The Exchange Rate Path Problem

In order to provide our customers a product that lets them spend cryptocurrencies to buy goods from merchants who only accept fiat currency, we need to solve two problems:

1. Determine a sequence of trades and transfers across exchanges to convert the cryptocurrency to fiat currency with a suitable exchange rate
2. Provide the best possible exchange rate to our customers

You are tasked with implementing a solution to this problem (details provided below). Please consider the following:

- Your solution should be production quality. You should implement your solution assuming that your code will be used in a production service.
- You may use whatever programming language you feel is most appropriate for solving this problem.
- You should be prepared to explain and justify the choices you made in your implementation.
- This technical exercise is a work-in-progress -- if something is unclear, please email your point of contact at TenX for clarification!
- We would prefer to receive your solution within a week of sending you the exercise. We also understand that your time is scarce -- if you will need more time, send your point of contact at TenX an email to let them know that you're still planning to submit a solution.
- We will evaluate your solution for:
    - correctness
    - clarity
    - maintainability
    - soundness

Input Data

You will receive a stream of price updates and exchange rate requests on stdin. Each price update or exchange rate request will be separated by a newline.

Price Updates

The price updates will be of the form:

```
<timestamp> <exchange> <source_currency> <destination_currency> <forward_factor>
<backward_factor>
```

Each field is separated by whitespace. For example,

```
2017-11-01T09:42:23+00:00 KRAKEN BTC USD 1000.0 0.0009
```

signifies that a price update was received from Kraken on November 1, 2017 at 9:42 am. The update says that 1 BTC is worth $1000 USD and that $1 USD is worth 0.0009 BTC.

The `forward_factor` and `backward_factor` will always multiply to a number that is less than or equal to 1.

Price updates are not guaranteed to arrive in chronological order. You should only consider the most recent price update for each `(source_currency, destination_currency)` pair when responding to an exchange rate request.

Exchange Rate Requests

Exchange rate requests will be:

```
EXCHANGE_RATE_REQUEST <source_exchange> <source_currency> <destination_exchange>
<destination_currency>
```

arriving as a line on stdin. This represents the question: What is the best exchange rate for converting `source_currency` on `source_exchange` into `destination_currency` on `destination_exchange`, and what trades and transfers need to be made to achieve that rate?

The Exchange Rate Graph

Each `(exchange, currency)` pair can be considered as a vertex in a graph. Vertices are created the first time a price update appears that references them. For the sake of this exercise, you can assume that vertices are never removed.

The vertices are connected with edges according to the following rules:

1. After receiving a price update, the edge from `(exchange, source_currency)` to `(exchange, destination_currency)` is assigned weight `forward_factor`, and the edge from `(exchange, destination_currency)` to `(exchange, source_currency)` is assigned weight `backward_factor`. For example, after receiving price update:

```
2017-11-01T09:42:23+00:00 KRAKEN BTC USD 1000.0 0.0009
```

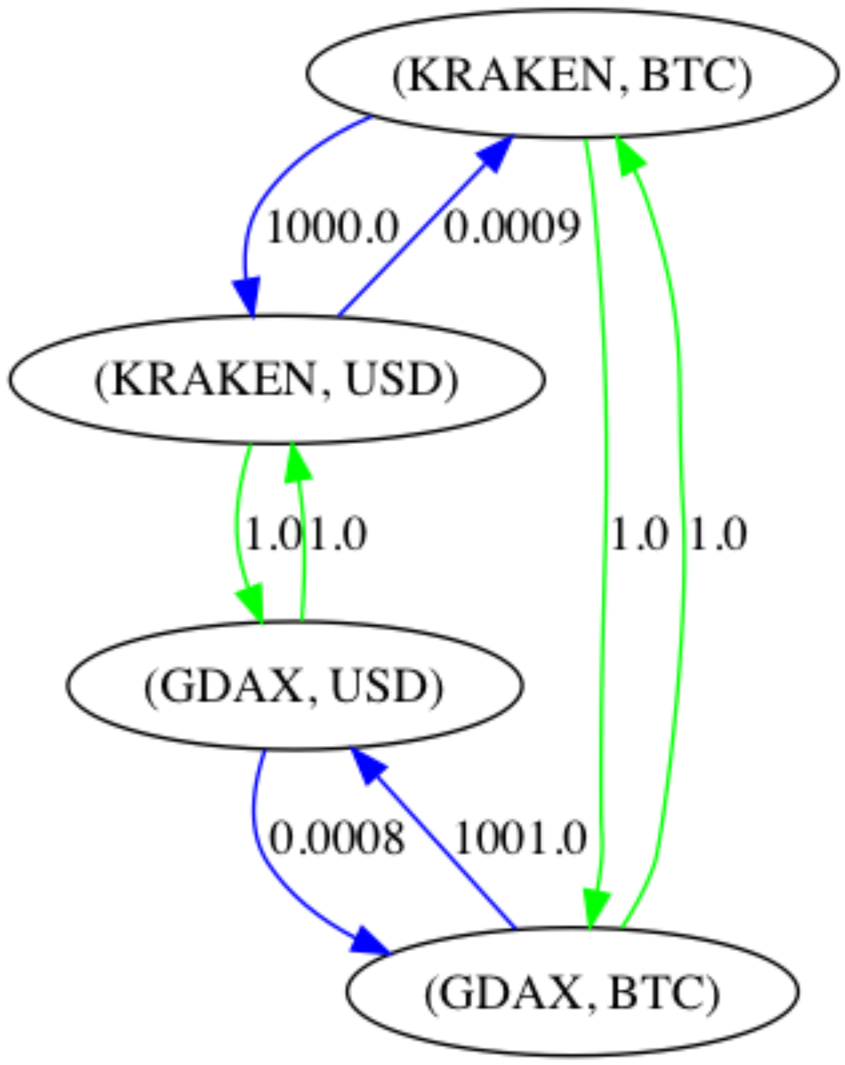
an edge from `(KRAKEN, BTC)` and `(KRAKEN, USD)` should be created if it does not already exist, and its edge weight should be assigned `1000.0`, and an edge from `(KRAKEN, USD)` to `(KRAKEN, BTC)` should be created if it does not already exist, and its edge weight should be assigned `0.0009`.

2. For each `currency`, each `(exchange, currency)` is connected to every other `(other_exchange, currency)` with an edge weight of `1.0`. For example, after receiving the price updates:

```
2017-11-01T09:42:23+00:00 KRAKEN BTC USD 1000.0 0.0009
2017-11-01T09:43:23+00:00 GDAX BTC USD 1001.0 0.0008
```

the graph would have the following edges:

```
(KRAKEN, BTC) -- 1000.0 --> (KRAKEN, USD)
(KRAKEN, USD) -- 0.0009 --> (KRAKEN, BTC)
(GDAX, BTC) -- 1001.0 --> (GDAX, USD)
(GDAX, USD) -- 0.0008 --> (GDAX, BTC)
(KRAKEN, BTC) -- 1.0 --> (GDAX, BTC)
(GDAX, BTC) -- 1.0 --> (KRAKEN, BTC)
(KRAKEN, USD) -- 1.0 --> (GDAX, USD)
(GDAX, USD) -- 1.0 --> (KRAKEN, USD)
```



Edges are never removed.

Finding the Best Exchange Rate

When you receive an exchange rate request, your job is to return the best possible exchange rate as well as the trades and transfers needed to achieve that rate. One way of achieving this is to use a modification of the Floyd-Warshall algorithm for finding the shortest paths between all pairs of vertices in a graph. If you're not familiar with the Floyd-Warshall algorithm and you're interested (**NOT** required for solving this exercise!), you can find more information about it here.

The variant we will use substitutes the `min` operator with `max`, and instead of using addition to concatenate paths, we will use multiplication. Don't worry if you're not familiar with graph algorithms, pseudocode for the algorithm is below!

```
let rate[][] = a lookup table of edge weights initialized to 0 for each
(source_vertex, destination_vertex) pair
let next[][] = a lookup table of vertices initialized to None for each
(source_vertex, destination_vertex) pair
let V[] = an array containing each vertex

procedure BestRates()
   for each edge (u,v)
      rate[u][v] ← w(u,v)  // the weight of the edge (u,v)
      next[u][v] ← v
   for k from 1 to length(V) // modified Floyd-Warshall implementation
      for i from 1 to length(V)
         for j from 1 to length(V)
            if rate[i][j] < rate[i][k] * rate[k][j] then
               rate[i][j] ← rate[i][k] * rate[k][j]
               next[i][j] ← next[i][k]

procedure Path(u, v)
   if next[u][v] = null then
       return []
   path = [u]
   while u ≠ v
       u ← next[u][v]
       path.append(u)
   return path
```

Output Format

For each exchange rate request line you receive on stdin, you should output to stdout:

```
BEST_RATES_BEGIN <source_exchange> <source_currency> <destination_exchange>
<destination_currency> <rate>
<source_exchange, source_currency>
<exchange, currency>
<exchange, currency>
...
<destination_exchange, destination_currency>
BEST_RATES_END
```

where `source_exchange`, `source_currency`, `destination_exchange`, and `destination_currency` are the respective exchanges and currencies from the exchange rate request received on stdin, and `rate` is the best rate found for converting from the `(source_exchange, source_currency)` to the `(destination_exchange, destination_currency)`using the algorithm.

After that, each line represents a vertex on the path in the graph. The vertices should be output one per line and in the same order as the path in the graph should be traversed according to the algorithm. This list of vertices should start with the `source_exchange, source_currency` pair and end with the `destination_exchange, destination_currency` pair.

After outputing the path, you should output the line `BEST_RATES_END`.

Submission

Please send your solution to us by sharing a link to a **private** Github or Bitbucket repository containing your code and instructions to build and run it. Please **DO NOT** send us archives or executable files as we will not be able to open them.

In case any part of the problem specification is unclear, please use your best judgement to implement a solution that you think best solves the underlying problem. You can discuss any uncertainties and resulting choices you made when you email us the link to the repository hosting your solution.

We will follow up with you after reviewing your work. You should be prepared to discuss your solution with us and to justify choices that you made while implementing it.

Good luck!