**Distributed Graphs Lab**

Semantic Data Management

Lab Report

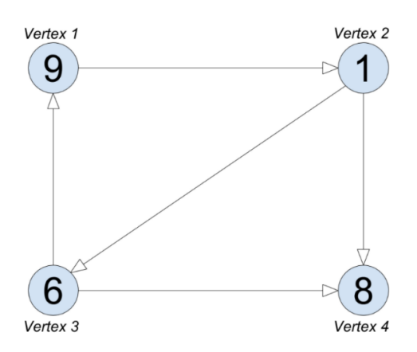
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## Exercise 1: Getting familiar with GraphX’s Pregel API

For the given graph:

The next supersteps will occur:

1. First superstep:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Vertex id | Initial state | Messages received | Result of calculations (merge) | Final state (apply) | Message sent (sendMsg) | Destination nodes (sendMsg) |
| 1 | 9 | Integer.  *MAX\_VALUE* | Integer.  *MAX\_VALUE* | 9 | 9 | 2 |
| 2 | 1 | Integer.  *MAX\_VALUE* | Integer.  *MAX\_VALUE* | 1 | - | - |
| 3 | 6 | Integer.  *MAX\_VALUE* | Integer.  *MAX\_VALUE* | 6 | - | - |
| 4 | 8 | Integer.  *MAX\_VALUE* | Integer.  *MAX\_VALUE* | 8 | - | - |

1. Second superstep:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Vertex id | Initial state | Messages received | Result of calculations (merge) | Final state (apply) | Message sent (sendMsg) | Destination nodes (sendMsg) |
| 1 | 9 | - | - | 9 | - | - |
| 2 | 1 | 9 | 9 | 9 | 9 | 3, 4 |
| 3 | 6 | - | - | 6 | - | - |
| 4 | 8 | - | - | 8 | - | - |

1. Third superstep:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Vertex id | Initial state | Messages received | Result of calculations (merge) | Final state (apply) | Message sent (sendMsg) | Destination nodes (sendMsg) |
| 1 | 9 | - | - | 9 | - | - |
| 2 | 9 | - | - | 9 | - | - |
| 3 | 6 | 9 | 9 | 9 | - | - |
| 4 | 8 | 9 | 9 | 9 | - | - |

After the third superstep, no messages are sent, so no vertex becomes active. Therefore, the algorithm stops with a max value of 9.

In the previous tables, we have filled some values in the “Result of calculations (merge)” and “Final state (apply)” columns, even though the function (merge and apply respectively) was not run in that particular case. In particular, merge was never run, since in no superstep a vertex received more than one message, and apply was only run in those cases in which the vertex received a message.

Similarly, in the “Message sent (sendMsg)” and “Destination nodes (sendMsg)” columns, we make no distinction in whether the sendMsg function was not run or it was but no message was sent. Like the apply function, sendMsg was only run in the cases that a vertex received a message.

## Exercise 2: Computing shortest path using Pregel

Functions implemented:

* *VProg*:

We keep the minimum value between the vertex value and the message received, since it represents the cost of the path.

* *sendMsg*:

If the vertex has been visited before (i.e., the value is not equal to Integer.*MAX\_VALUE*) and the sum of its value and the edge connecting it into a neighbor is less than the value of this neighbor (i.e., a shorter path has been found for the neighbor), it sends it a message.

To make this function more readable, an intermediate class with helper functions has been defined (sendMessage). This class has been used in this and the next exercise.

* *merge:*

We keep the message with the lowest value (shortest path).

## Exercise 3: Extending shortest path’s computation

Vertex structure:

In addition to the value of the shortest path, each vertex is also holding the actual sequence of vertex of that shortest path. Therefore, the value that holds is a tuple of an integer and a list (holding the path) instead of just an integer as in the previous exercise.

Functions implemented:

* *VProg*:

Same as exercise 2 (keep minimum value).

* *sendMsg*:

Same as exercise 2, but since we are also keeping the path, the message contains the new value and the new path, which is constructed by appending the source vertex id to the path hold by the source vertex.

* *merge:*

Same as exercise 2 (keep minimum value).

## Exercise 4: Spark Graph Frames

Assumptions:

The damping factor used for the algorithm will be 0.85, which is the value normally used according to Wikipedia [1].

We choose the number of iterations so that the average difference in the PageRank values is below a certain threshold (we use 0.0001, which is the same value used for TextRank [2]). The following table shows the differences for each iteration, as can be seen, this value falls behind the threshold at 20 iterations.

|  |  |
| --- | --- |
| #Iterations | Average PageRank Difference |
| 10 | 0,008594 |
| 11 | 0,006297 |
| 12 | 0,002808 |
| 13 | 0,002065 |
| 14 | 0,001026 |
| 15 | 0,000719 |
| 16 | 0,000391 |
| 17 | 0,000266 |
| 18 | 0,000151 |
| 19 | 0,000101 |
| 20 | 0,000059 |

We can see that the convergence starts at around 15 iterations and thus, this is the value we choose for the algorithm.

## References

**[1]** Wikipedia contributors. (2022, 24 abril). PageRank. Wikipedia.

https://tinyurl.com/5y3k6su5

[2] Mihalcea, Rada & Tarau, Paul. (2004). TextRank: Bringing Order into Text.

https://tinyurl.com/46wuh2f9