Solutions for Exercise No. 1
07.03.2017

Relational Algebra

1. The names of all islands that are volcanic or coral. You may use the constants 'volcanic' and 'coral'.

\[ \pi_{\text{Name}}(\sigma_{\text{Type}='\text{volcanic}' \lor \text{Type}='\text{coral}'}(\text{island})) \]

2. The names of all rivers that flow through at least two different provinces of the same country.

\[ \pi_{\text{River}}( \text{geoRiver} \Join \sigma_{\text{Country}=\text{C1} \land \text{River}=\text{R1} \land \text{Province} \neq \text{P1} \land (\text{Population} \div \text{Area}) < (\text{P1} \div \text{A1})}(\rho_{(\text{R1,C1,P1})}(\text{geoRiver})) ) \]

3. The name(s) of the Swiss province(s) with the highest ratio of inhabitants per area. You may only use the country code 'CH'.

\[ \text{swissProvince} \leftarrow \sigma_{\text{Country}='\text{CH}'}(\text{province}) \]

\[ \pi_{\text{Name}}(\text{swissProvince}) - \pi_{\text{Name}}( \text{swissProvince} \Join \rho_{(\text{P1,A1})}(\pi_{\text{Population},\text{Area}}(\text{swissProvince}))) \]

4. The codes of all countries that have a border length of more than 100km with at least one neighboring country. You may use the names of the oceans in your expression.

\[ \pi_{\text{Country}}(\sigma_{\text{Sea}='\text{Pacific Ocean}' \lor \text{Sea}='\text{Atlantic Ocean}'}(\text{geoSea})) - \pi_{\text{Country}}(\sigma_{\text{Sea}='\text{Pacific Ocean}'}(\text{geoSea})) \cup \pi_{\text{Country}}(\sigma_{\text{Sea}='\text{Atlantic Ocean}'}(\text{geoSea})) - \pi_{\text{Country}}(\sigma_{\text{Sea}='\text{Pacific Ocean}'}(\text{geoSea})) \]

Alternative solution:

\[ (\pi_{\text{Country}}(\sigma_{\text{Sea}='\text{Atlantic Ocean}'}(\text{geoSea})) - \pi_{\text{Country}}(\sigma_{\text{Sea}='\text{Pacific Ocean}'}(\text{geoSea}))) \cup (\pi_{\text{Country}}(\sigma_{\text{Sea}='\text{Pacific Ocean}'}(\text{geoSea})) - \pi_{\text{Country}}(\sigma_{\text{Sea}='\text{Atlantic Ocean}'}(\text{geoSea}))) \]

5. The names and codes of all countries that have a border length of more than 100km with at least one neighboring country.

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How often is the code of a country contained in the result if the country has a border length of more than 100km with 3 neighboring countries? Explain.

\[\pi_{\text{Name}, \text{Code}}(\text{country} \bowtie \text{Length}>100 \land (\text{Code} = \text{Country1} \lor \text{Code} = \text{Country2}) \bowtie \text{borders})\]

As the code of a country is unique (primary key in the country relation) and the relational algebra is set-based, i.e., there do not exist two tuples with the same values in the corresponding attributes, the code of a country is only contained in one tuple in the query result.

6. State precisely in natural language what the following relational algebra expression computes.

\[\pi_{\text{Name}}(\pi_{\text{Name}, \text{Code}}(\text{country}) - \pi_{\text{Name}, \text{Code}}(\sigma_{\text{Length}<100}(\text{borders} \bowtie \text{Code} = \text{Country1} \lor \text{Country2} \bowtie \text{country})))\]

There exist database instances on which the above relational algebra expression and a modified expression that does not contain the country code in the two projections when calculating the difference evaluate to different results. Explain and give an example.

Solution:
The expression computes the name of the countries that have a common border of at least 100km length with all of their neighboring countries. The result includes countries without any neighboring country (as the condition is trivially fulfilled).

The primary key of the country relation is the Code attribute. Thus, there might exist two countries with distinct country codes but with the same name. If one of the countries has such a border with all of their neighboring countries and the other country does not, projecting solely on the country’s name would result in also removing the country that fulfills the condition. In the following example, Switzerland with country code 'CH' would be removed from the result relation when solely projecting on the Name attribute. The reason is that Switzerland with country code 'ABC' has a border with Germany of length 50 and therefore does not fulfill the condition.

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<th>country</th>
<th>Name</th>
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<td>7207060</td>
</tr>
<tr>
<td>'ABC'</td>
<td>Switzerland</td>
<td>'F'</td>
<td>'G'</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>'D'</td>
<td>Germany</td>
<td>'Berlin'</td>
<td>'Berlin'</td>
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<td>83536115</td>
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<table>
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<th>Length</th>
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<tbody>
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