

**CSE 601 – Homework 2**

**Mining Association Rules from Gene Expression  
Data**

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## Part 1

### Task

Implement the Apriori algorithm to find all frequent itemsets. Report the number of frequent itemsets for support of 30%, 40%, 50%, 60%, and 70%, respectively.

### Implementation Details about Apriori Algorithm

The input data is taken from gene\_expression.txt file. We read the file from the .txt file using a BufferedReader in Java. Each line is read one at a time and we split the terms with a tab delimiter. In each line the first term is considered to be the symptom and the rest are the geneset for the symptom. In the input file the genes are given as up and down. We append "G" and the position of it to the value of term to generate our itemset. The Apriori algorithm is performed on this itemset. In our implementation we called the itemset as transactions. Transactions are generated by the function parse and stores as an ArrayList.

The program takes the text file and the Minimum support count as the input. There are two steps in our implementation of this algorithm. We first generate the candidate itemset using the function generateCandidateItemset. This generates the combination of size N depending on the stage of the call and populates the ArrayList candidateItemset. This itemset is then pruned to get the frequent item set. To perform pruning, the number of occurrences of each combination in the given transaction is recorded in a HashMap frequentItemsetMap. If the count(value of itemset in map) is less than the minimum support count, then the combination is eliminated. This is performed by generateFrequentItemset. The process of forming combination of size N is stopped when no further combination can be produces. Following the requirement the output at each minimum support count is the number of itemsets at each possible length that can be generated and the total of number of itemsets at each stage.

### Result

Support is set to be : 70%  
number of length-1 frequent itemset: 7  
Total:7  
Support is set to be : 60%  
number of length-1 frequent itemset: 34  
number of length-2 frequent itemset: 2  
Total:36  
Support is set to be : 50%  
number of length-1 frequent itemset: 109  
number of length-2 frequent itemset: 63  
number of length-3 frequent itemset: 2  
Total:174  
Support is set to be : 40%  
number of length-1 frequent itemset: 167  
number of length-2 frequent itemset: 753  
number of length-3 frequent itemset: 149  
number of length-4 frequent itemset: 7  
number of length-5 frequent itemset: 1  
Total:1077  
Support is set to be : 50  
number of length-1 frequent itemset: 109

number of length-2 frequent itemset: 63

{[G72\_UP]}->{[G32\_Down]}  
{[G32\_Down]}->{[G72\_UP]}  
{[G97\_Down]}->{[G82\_Down]}  
{[G82\_Down]}->{[G97\_Down]}  
{[G88\_Down]}->{[G24\_Down]}  
{[G24\_Down]}->{[G88\_Down]}  
{[G94\_UP]}->{[G38\_Down]}  
{[G38\_Down]}->{[G94\_UP]}  
{[G52\_Down]}->{[G28\_Down]}  
{[G28\_Down]}->{[G52\_Down]}  
{[G41\_Down]}->{[G38\_Down]}  
{[G38\_Down]}->{[G41\_Down]}  
{[G59\_UP]}->{[G38\_Down]}  
{[G38\_Down]}->{[G59\_UP]}  
{[G28\_Down]}->{[G10\_Down]}  
{[G10\_Down]}->{[G28\_Down]}  
{[G6\_UP]}->{[G38\_Down]}  
{[G38\_Down]}->{[G6\_UP]}  
{[G88\_Down]}->{[G41\_Down]}  
{[G41\_Down]}->{[G88\_Down]}  
{[G6\_UP]}->{[G28\_Down]}  
{[G28\_Down]}->{[G6\_UP]}  
{[G96\_Down]}->{[G59\_UP]}  
{[G59\_UP]}->{[G96\_Down]}  
{[G97\_Down]}->{[G72\_UP]}  
{[G72\_UP]}->{[G97\_Down]}  
{[G67\_UP]}->{[G1\_UP]}  
{[G1\_UP]}->{[G67\_UP]}  
{[G32\_Down]}->{[G28\_Down]}  
{[G28\_Down]}->{[G32\_Down]}  
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{[G2\_Down]}->{[G38\_Down]}  
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{[G28\_Down]}->{[G47\_UP]}  
{[G88\_Down]}->{[G38\_Down]}  
{[G38\_Down]}->{[G88\_Down]}  
{[G94\_UP]}->{[G10\_Down]}  
{[G10\_Down]}->{[G94\_UP]}  
{[G41\_Down]}->{[G28\_Down]}  
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{[G67\_UP]}->{[G38\_Down]}  
{[G38\_Down]}->{[G67\_UP]}  
{[G72\_UP]}->{[G1\_UP]}  
{[G1\_UP]}->{[G72\_UP]}  
{[G72\_UP]}->{[G13\_Down]}  
{[G13\_Down]}->{[G72\_UP]}  
{[G59\_UP]}->{[G13\_Down]}  
{[G13\_Down]}->{[G59\_UP]}  
{[G72\_UP]}->{[G38\_Down]}  
{[G38\_Down]}->{[G72\_UP]}  
{[G38\_Down]}->{[G10\_Down]}  
{[G10\_Down]}->{[G38\_Down]}  
{[G82\_Down]}->{[G72\_UP]}

{[G72\_UP]}->{[G82\_Down]}\n{\nG88\_Down]}->{[G54\_UP]}\n{\nG54\_UP]}->{[G88\_Down]}\n{\nG2\_Down]}->{[G28\_Down]}\n{\nG28\_Down]}->{[G2\_Down]}\n{\nG59\_UP]}->{[G32\_Down]}\n{\nG32\_Down]}->{[G59\_UP]}\n{\nG6\_UP]}->{[G32\_Down]}\n{\nG32\_Down]}->{[G6\_UP]}\n{\nG88\_Down]}->{[G28\_Down]}\n{\nG28\_Down]}->{[G88\_Down]}\n{\nG82\_Down]}->{[G59\_UP]}\n{\nG59\_UP]}->{[G82\_Down]}\n{\nG59\_UP]}->{[G10\_Down]}\n{\nG10\_Down]}->{[G59\_UP]}\n{\nG88\_Down]}->{[G10\_Down]}\n{\nG10\_Down]}->{[G88\_Down]}\n{\nG54\_UP]}->{[G1\_UP]}\n{\nG1\_UP]}->{[G54\_UP]}\n{\nG87\_UP]}->{[G28\_Down]}\n{\nG28\_Down]}->{[G87\_UP]}\n{\nG8\_UP]}->{[G88\_Down]}\n{\nG88\_Down]}->{[G8\_UP]}\n{\nG96\_Down]}->{[G72\_UP]}\n{\nG72\_UP]}->{[G96\_Down]}\n{\nG47\_UP]}->{[G38\_Down]}\n{\nG38\_Down]}->{[G47\_UP]}\n{\nG52\_Down]}->{[G38\_Down]}\n{\nG38\_Down]}->{[G52\_Down]}\n{\nG88\_Down]}->{[G87\_UP]}\n{\nG87\_UP]}->{[G88\_Down]}\n{\nG72\_UP]}->{[G59\_UP]}\n{\nG59\_UP]}->{[G72\_UP]}\n{\nG54\_UP]}->{[G24\_Down]}\n{\nG24\_Down]}->{[G54\_UP]}\n{\nG70\_Down]}->{[G1\_UP]}\n{\nG1\_UP]}->{[G70\_Down]}\n{\nG91\_UP]}->{[G38\_Down]}\n{\nG38\_Down]}->{[G91\_UP]}\n{\nG65\_Down]}->{[G38\_Down]}\n{\nG38\_Down]}->{[G65\_Down]}\n{\nG70\_Down]}->{[G38\_Down]}\n{\nG38\_Down]}->{[G70\_Down]}\n{\nG88\_Down]}->{[G59\_UP]}\n{\nG59\_UP]}->{[G88\_Down]}\n{\nG82\_Down]}->{[G13\_Down]}\n{\nG13\_Down]}->{[G82\_Down]}\n{\nG96\_Down]}->{[G82\_Down]}\n{\nG82\_Down]}->{[G96\_Down]}\n{\nG87\_UP]}->{[G59\_UP]}\n{\nG59\_UP]}->{[G87\_UP]}\n{\nG59\_UP]}->{[G1\_UP]}\n{\nG1\_UP]}->{[G59\_UP]}\n{\nG70\_Down]}->{[G10\_Down]}\n{\nG10\_Down]}->{[G70\_Down]}\n{\nG47\_UP]}->{[G10\_Down]}

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{[G10_Down]}->{[G47_UP]}
{[G38_Down]}->{[G28_Down]}
{[G28_Down]}->{[G38_Down]}
{[G38_Down]}->{[G1_UP]}
{[G1_UP]}->{[G38_Down]}
{[G28_Down]}->{[G13_Down]}
{[G13_Down]}->{[G28_Down]}
{[G59_UP]}->{[G28_Down]}
{[G28_Down]}->{[G59_UP]}
{[G1_UP]}->{[G10_Down]}
{[G10_Down]}->{[G1_UP]}
{[G6_UP]}->{[G13_Down]}
{[G13_Down]}->{[G6_UP]}
{[G38_Down]}->{[G32_Down]}
{[G32_Down]}->{[G38_Down]}
{[G72_UP, G82_Down]}->{[G59_UP]}
{[G59_UP, G82_Down]}->{[G72_UP]}
{[G59_UP, G72_UP]}->{[G82_Down]}
{[G82_Down]}->{[G59_UP, G72_UP]}
{[G59_UP]}->{[G72_UP, G82_Down]}
{[G72_UP]}->{[G59_UP, G82_Down]}
{[G72_UP, G96_Down]}->{[G59_UP]}
{[G59_UP, G96_Down]}->{[G72_UP]}
{[G59_UP, G72_UP]}->{[G96_Down]}
{[G96_Down]}->{[G59_UP, G72_UP]}
{[G59_UP]}->{[G72_UP, G96_Down]}
{[G72_UP]}->{[G59_UP, G96_Down]}

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number of length-3 frequent itemset: 2

Total:174

Total number of rules generated : 138

Number of rules generated from query(RULE HAS ANY OF G6\_UP) : 10

```

{[G6_UP]}->{[G38_Down]}
{[G38_Down]}->{[G6_UP]}
{[G6_UP]}->{[G28_Down]}
{[G28_Down]}->{[G6_UP]}
{[G6_UP]}->{[G59_UP]}
{[G59_UP]}->{[G6_UP]}
{[G6_UP]}->{[G32_Down]}
{[G32_Down]}->{[G6_UP]}
{[G6_UP]}->{[G13_Down]}
{[G13_Down]}->{[G6_UP]}

```

Number of rules generated from query(RULE HAS 1 OF G1\_UP) : 14

```

{[G67_UP]}->{[G1_UP]}
{[G1_UP]}->{[G67_UP]}
{[G72_UP]}->{[G1_UP]}
{[G1_UP]}->{[G72_UP]}
{[G54_UP]}->{[G1_UP]}
{[G1_UP]}->{[G54_UP]}
{[G70_Down]}->{[G1_UP]}
{[G1_UP]}->{[G70_Down]}
{[G59_UP]}->{[G1_UP]}
{[G1_UP]}->{[G59_UP]}
{[G38_Down]}->{[G1_UP]}
{[G1_UP]}->{[G38_Down]}
{[G1_UP]}->{[G10_Down]}
{[G10_Down]}->{[G1_UP]}

```

Number of rules generated from query(RULE HAS 1 OF (G1\_UP, G10\_DOWN)) : 26

{[G28\_Down]}->{[G10\_Down]}  
{[G10\_Down]}->{[G28\_Down]}  
{[G67\_UP]}->{[G1\_UP]}  
{[G1\_UP]}->{[G67\_UP]}  
{[G94\_UP]}->{[G10\_Down]}  
{[G10\_Down]}->{[G94\_UP]}  
{[G72\_UP]}->{[G1\_UP]}  
{[G1\_UP]}->{[G72\_UP]}  
{[G38\_Down]}->{[G10\_Down]}  
{[G10\_Down]}->{[G38\_Down]}  
{[G59\_UP]}->{[G10\_Down]}  
{[G10\_Down]}->{[G59\_UP]}  
{[G88\_Down]}->{[G10\_Down]}  
{[G10\_Down]}->{[G88\_Down]}  
{[G54\_UP]}->{[G1\_UP]}  
{[G1\_UP]}->{[G54\_UP]}  
{[G70\_Down]}->{[G1\_UP]}  
{[G1\_UP]}->{[G70\_Down]}  
{[G59\_UP]}->{[G1\_UP]}  
{[G1\_UP]}->{[G59\_UP]}  
{[G70\_Down]}->{[G10\_Down]}  
{[G10\_Down]}->{[G70\_Down]}  
{[G47\_UP]}->{[G10\_Down]}  
{[G10\_Down]}->{[G47\_UP]}  
{[G38\_Down]}->{[G1\_UP]}  
{[G1\_UP]}->{[G38\_Down]}

Number of rules generated from query(BODY HAS ANY OF G6\_UP) : 5

{[G6\_UP]}->{[G38\_Down]}  
{[G6\_UP]}->{[G28\_Down]}  
{[G6\_UP]}->{[G59\_UP]}  
{[G6\_UP]}->{[G32\_Down]}  
{[G6\_UP]}->{[G13\_Down]}

Number of rules generated from query(BODY HAS NONE OF G72\_UP) : 124

{[G32\_Down]}->{[G72\_UP]}  
{[G97\_Down]}->{[G82\_Down]}  
{[G82\_Down]}->{[G97\_Down]}  
{[G88\_Down]}->{[G24\_Down]}  
{[G24\_Down]}->{[G88\_Down]}  
{[G94\_UP]}->{[G38\_Down]}  
{[G38\_Down]}->{[G94\_UP]}  
{[G52\_Down]}->{[G28\_Down]}  
{[G28\_Down]}->{[G52\_Down]}  
{[G41\_Down]}->{[G38\_Down]}  
{[G38\_Down]}->{[G41\_Down]}  
{[G59\_UP]}->{[G38\_Down]}  
{[G38\_Down]}->{[G59\_UP]}  
{[G28\_Down]}->{[G10\_Down]}  
{[G10\_Down]}->{[G28\_Down]}  
{[G6\_UP]}->{[G38\_Down]}  
{[G38\_Down]}->{[G6\_UP]}  
{[G88\_Down]}->{[G41\_Down]}  
{[G41\_Down]}->{[G88\_Down]}  
{[G6\_UP]}->{[G28\_Down]}  
{[G28\_Down]}->{[G6\_UP]}  
{[G96\_Down]}->{[G59\_UP]}

{[G59\_UP]}->{[G96\_Down]}  
{[G97\_Down]}->{[G72\_UP]}  
{[G67\_UP]}->{[G1\_UP]}  
{[G1\_UP]}->{[G67\_UP]}  
{[G32\_Down]}->{[G28\_Down]}  
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{[G59\_UP]}->{[G13\_Down]}  
{[G13\_Down]}->{[G59\_UP]}  
{[G38\_Down]}->{[G72\_UP]}  
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{[G10\_Down]}->{[G38\_Down]}  
{[G82\_Down]}->{[G72\_UP]}  
{[G88\_Down]}->{[G54\_UP]}  
{[G54\_UP]}->{[G88\_Down]}  
{[G2\_Down]}->{[G28\_Down]}  
{[G28\_Down]}->{[G2\_Down]}  
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{[G32\_Down]}->{[G59\_UP]}  
{[G6\_UP]}->{[G32\_Down]}  
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{[G10\_Down]}->{[G88\_Down]}  
{[G54\_UP]}->{[G1\_UP]}  
{[G1\_UP]}->{[G54\_UP]}  
{[G87\_UP]}->{[G28\_Down]}  
{[G28\_Down]}->{[G87\_UP]}  
{[G8\_UP]}->{[G88\_Down]}  
{[G88\_Down]}->{[G8\_UP]}  
{[G96\_Down]}->{[G72\_UP]}  
{[G47\_UP]}->{[G38\_Down]}  
{[G38\_Down]}->{[G47\_UP]}  
{[G52\_Down]}->{[G38\_Down]}  
{[G38\_Down]}->{[G52\_Down]}  
{[G88\_Down]}->{[G87\_UP]}

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{[G87_UP]}->{[G88_Down]}
{[G59_UP]}->{[G72_UP]}
{[G54_UP]}->{[G24_Down]}
{[G24_Down]}->{[G54_UP]}
{[G70_Down]}->{[G1_UP]}
{[G1_UP]}->{[G70_Down]}
{[G91_UP]}->{[G38_Down]}
{[G38_Down]}->{[G91_UP]}
{[G65_Down]}->{[G38_Down]}
{[G38_Down]}->{[G65_Down]}
{[G70_Down]}->{[G38_Down]}
{[G38_Down]}->{[G70_Down]}
{[G88_Down]}->{[G59_UP]}
{[G59_UP]}->{[G88_Down]}
{[G82_Down]}->{[G13_Down]}
{[G13_Down]}->{[G82_Down]}
{[G96_Down]}->{[G82_Down]}
{[G82_Down]}->{[G96_Down]}
{[G87_UP]}->{[G59_UP]}
{[G59_UP]}->{[G87_UP]}
{[G59_UP]}->{[G1_UP]}
{[G1_UP]}->{[G59_UP]}
{[G70_Down]}->{[G10_Down]}
{[G10_Down]}->{[G70_Down]}
{[G47_UP]}->{[G10_Down]}
{[G10_Down]}->{[G47_UP]}
{[G38_Down]}->{[G28_Down]}
{[G28_Down]}->{[G38_Down]}
{[G38_Down]}->{[G1_UP]}
{[G1_UP]}->{[G38_Down]}
{[G28_Down]}->{[G13_Down]}
{[G13_Down]}->{[G28_Down]}
{[G59_UP]}->{[G28_Down]}
{[G28_Down]}->{[G59_UP]}
{[G1_UP]}->{[G10_Down]}
{[G10_Down]}->{[G1_UP]}
{[G6_UP]}->{[G13_Down]}
{[G13_Down]}->{[G6_UP]}
{[G38_Down]}->{[G32_Down]}
{[G32_Down]}->{[G38_Down]}
{[G59_UP, G82_Down]}->{[G72_UP]}
{[G82_Down]}->{[G59_UP, G72_UP]}
{[G59_UP]}->{[G72_UP, G82_Down]}
{[G59_UP, G96_Down]}->{[G72_UP]}
{[G96_Down]}->{[G59_UP, G72_UP]}
{[G59_UP]}->{[G72_UP, G96_Down]}

```

Number of rules generated from query(RULE HAS 1 OF (G1\_UP, G10\_DOWN)) : 15

```

{[G10_Down]}->{[G28_Down]}
{[G1_UP]}->{[G67_UP]}
{[G10_Down]}->{[G94_UP]}
{[G1_UP]}->{[G72_UP]}
{[G10_Down]}->{[G38_Down]}
{[G10_Down]}->{[G59_UP]}
{[G10_Down]}->{[G88_Down]}
{[G1_UP]}->{[G54_UP]}
{[G1_UP]}->{[G70_Down]}

```



{[G1\_UP]}->{[G59\_UP]}  
{[G10\_Down]}->{[G70\_Down]}  
{[G10\_Down]}->{[G47\_UP]}  
{[G1\_UP]}->{[G38\_Down]}  
{[G1\_UP]}->{[G10\_Down]}  
{[G10\_Down]}->{[G1\_UP]}

Number of rules generated from query(HEAD HAS ANY OF G6\_UP) : 5

{[G38\_Down]}->{[G6\_UP]}  
{[G28\_Down]}->{[G6\_UP]}  
{[G59\_UP]}->{[G6\_UP]}  
{[G32\_Down]}->{[G6\_UP]}  
{[G13\_Down]}->{[G6\_UP]}

Number of rules generated from query(HEAD HAS NONE OF G1\_UP,G6\_UP) : 126

{[G72\_UP]}->{[G32\_Down]}  
{[G32\_Down]}->{[G72\_UP]}  
{[G97\_Down]}->{[G82\_Down]}  
{[G82\_Down]}->{[G97\_Down]}  
{[G88\_Down]}->{[G24\_Down]}  
{[G24\_Down]}->{[G88\_Down]}  
{[G94\_UP]}->{[G38\_Down]}  
{[G38\_Down]}->{[G94\_UP]}  
{[G52\_Down]}->{[G28\_Down]}  
{[G28\_Down]}->{[G52\_Down]}  
{[G41\_Down]}->{[G38\_Down]}  
{[G38\_Down]}->{[G41\_Down]}  
{[G59\_UP]}->{[G38\_Down]}  
{[G38\_Down]}->{[G59\_UP]}  
{[G28\_Down]}->{[G10\_Down]}  
{[G10\_Down]}->{[G28\_Down]}  
{[G6\_UP]}->{[G38\_Down]}  
{[G88\_Down]}->{[G41\_Down]}  
{[G41\_Down]}->{[G88\_Down]}  
{[G6\_UP]}->{[G28\_Down]}  
{[G96\_Down]}->{[G59\_UP]}  
{[G59\_UP]}->{[G96\_Down]}  
{[G97\_Down]}->{[G72\_UP]}  
{[G72\_UP]}->{[G97\_Down]}  
{[G1\_UP]}->{[G67\_UP]}  
{[G32\_Down]}->{[G28\_Down]}  
{[G28\_Down]}->{[G32\_Down]}  
{[G38\_Down]}->{[G2\_Down]}  
{[G2\_Down]}->{[G38\_Down]}  
{[G47\_UP]}->{[G28\_Down]}  
{[G28\_Down]}->{[G47\_UP]}  
{[G88\_Down]}->{[G38\_Down]}  
{[G38\_Down]}->{[G88\_Down]}  
{[G94\_UP]}->{[G10\_Down]}  
{[G10\_Down]}->{[G94\_UP]}  
{[G41\_Down]}->{[G28\_Down]}  
{[G28\_Down]}->{[G41\_Down]}  
{[G6\_UP]}->{[G59\_UP]}  
{[G67\_UP]}->{[G38\_Down]}  
{[G38\_Down]}->{[G67\_UP]}  
{[G1\_UP]}->{[G72\_UP]}  
{[G72\_UP]}->{[G13\_Down]}  
{[G13\_Down]}->{[G72\_UP]}

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{{G59_UP}}->{{G13_Down}}
{{G13_Down}}->{{G59_UP}}
{{G72_UP}}->{{G38_Down}}
{{G38_Down}}->{{G72_UP}}
{{G38_Down}}->{{G10_Down}}
{{G10_Down}}->{{G38_Down}}
{{G82_Down}}->{{G72_UP}}
{{G72_UP}}->{{G82_Down}}
{{G88_Down}}->{{G54_UP}}
{{G54_UP}}->{{G88_Down}}
{{G2_Down}}->{{G28_Down}}
{{G28_Down}}->{{G2_Down}}
{{G59_UP}}->{{G32_Down}}
{{G32_Down}}->{{G59_UP}}
{{G6_UP}}->{{G32_Down}}
{{G88_Down}}->{{G28_Down}}
{{G28_Down}}->{{G88_Down}}
{{G82_Down}}->{{G59_UP}}
{{G59_UP}}->{{G82_Down}}
{{G59_UP}}->{{G10_Down}}
{{G10_Down}}->{{G59_UP}}
{{G88_Down}}->{{G10_Down}}
{{G10_Down}}->{{G88_Down}}
{{G1_UP}}->{{G54_UP}}
{{G87_UP}}->{{G28_Down}}
{{G28_Down}}->{{G87_UP}}
{{G8_UP}}->{{G88_Down}}
{{G88_Down}}->{{G8_UP}}
{{G96_Down}}->{{G72_UP}}
{{G72_UP}}->{{G96_Down}}
{{G47_UP}}->{{G38_Down}}
{{G38_Down}}->{{G47_UP}}
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{{G38_Down}}->{{G52_Down}}
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{{G87_UP}}->{{G88_Down}}
{{G72_UP}}->{{G59_UP}}
{{G59_UP}}->{{G72_UP}}
{{G54_UP}}->{{G24_Down}}
{{G24_Down}}->{{G54_UP}}
{{G1_UP}}->{{G70_Down}}
{{G91_UP}}->{{G38_Down}}
{{G38_Down}}->{{G91_UP}}
{{G65_Down}}->{{G38_Down}}
{{G38_Down}}->{{G65_Down}}
{{G70_Down}}->{{G38_Down}}
{{G38_Down}}->{{G70_Down}}
{{G88_Down}}->{{G59_UP}}
{{G59_UP}}->{{G88_Down}}
{{G82_Down}}->{{G13_Down}}
{{G13_Down}}->{{G82_Down}}
{{G96_Down}}->{{G82_Down}}
{{G82_Down}}->{{G96_Down}}
{{G87_UP}}->{{G59_UP}}
{{G59_UP}}->{{G87_UP}}
{{G1_UP}}->{{G59_UP}}

```

```

{[G70_Down]}->{[G10_Down]}
{[G10_Down]}->{[G70_Down]}
{[G47_UP]}->{[G10_Down]}
{[G10_Down]}->{[G47_UP]}
{[G38_Down]}->{[G28_Down]}
{[G28_Down]}->{[G38_Down]}
{[G1_UP]}->{[G38_Down]}
{[G28_Down]}->{[G13_Down]}
{[G13_Down]}->{[G28_Down]}
{[G59_UP]}->{[G28_Down]}
{[G28_Down]}->{[G59_UP]}
{[G1_UP]}->{[G10_Down]}
{[G6_UP]}->{[G13_Down]}
{[G38_Down]}->{[G32_Down]}
{[G32_Down]}->{[G38_Down]}
{[G72_UP, G82_Down]}->{[G59_UP]}
{[G59_UP, G82_Down]}->{[G72_UP]}
{[G59_UP, G72_UP]}->{[G82_Down]}
{[G82_Down]}->{[G59_UP, G72_UP]}
{[G59_UP]}->{[G72_UP, G82_Down]}
{[G72_UP]}->{[G59_UP, G82_Down]}
{[G72_UP, G96_Down]}->{[G59_UP]}
{[G59_UP, G96_Down]}->{[G72_UP]}
{[G59_UP, G72_UP]}->{[G96_Down]}
{[G96_Down]}->{[G59_UP, G72_UP]}
{[G59_UP]}->{[G72_UP, G96_Down]}
{[G72_UP]}->{[G59_UP, G96_Down]}

```

Number of rules generated from query(HEAD HAS 1 OF G6\_UP,G8\_UP) : 6

```

{[G38_Down]}->{[G6_UP]}
{[G28_Down]}->{[G6_UP]}
{[G59_UP]}->{[G6_UP]}
{[G32_Down]}->{[G6_UP]}
{[G88_Down]}->{[G8_UP]}
{[G13_Down]}->{[G6_UP]}

```

Number of rules generated from query(RULE HAS 1 OF G1\_UP, G6\_UP, G72\_UP) : 48

```

{[G72_UP]}->{[G32_Down]}
{[G32_Down]}->{[G72_UP]}
{[G6_UP]}->{[G38_Down]}
{[G38_Down]}->{[G6_UP]}
{[G6_UP]}->{[G28_Down]}
{[G28_Down]}->{[G6_UP]}
{[G97_Down]}->{[G72_UP]}
{[G72_UP]}->{[G97_Down]}
{[G67_UP]}->{[G1_UP]}
{[G1_UP]}->{[G67_UP]}
{[G6_UP]}->{[G59_UP]}
{[G59_UP]}->{[G6_UP]}
{[G72_UP]}->{[G13_Down]}
{[G13_Down]}->{[G72_UP]}
{[G72_UP]}->{[G38_Down]}
{[G38_Down]}->{[G72_UP]}
{[G82_Down]}->{[G72_UP]}
{[G72_UP]}->{[G82_Down]}
{[G6_UP]}->{[G32_Down]}
{[G32_Down]}->{[G6_UP]}
{[G54_UP]}->{[G1_UP]}

```

```

{{G1_UP}}->{{G54_UP}}
{{G96_Down}}->{{G72_UP}}
{{G72_UP}}->{{G96_Down}}
{{G72_UP}}->{{G59_UP}}
{{G59_UP}}->{{G72_UP}}
{{G70_Down}}->{{G1_UP}}
{{G1_UP}}->{{G70_Down}}
{{G59_UP}}->{{G1_UP}}
{{G1_UP}}->{{G59_UP}}
{{G38_Down}}->{{G1_UP}}
{{G1_UP}}->{{G38_Down}}
{{G1_UP}}->{{G10_Down}}
{{G10_Down}}->{{G1_UP}}
{{G6_UP}}->{{G13_Down}}
{{G13_Down}}->{{G6_UP}}
{{G72_UP, G82_Down}}->{{G59_UP}}
{{G59_UP, G82_Down}}->{{G72_UP}}
{{G59_UP, G72_UP}}->{{G82_Down}}
{{G82_Down}}->{{G59_UP, G72_UP}}
{{G59_UP}}->{{G72_UP, G82_Down}}
{{G72_UP}}->{{G59_UP, G82_Down}}
{{G72_UP, G96_Down}}->{{G59_UP}}
{{G59_UP, G96_Down}}->{{G72_UP}}
{{G59_UP, G72_UP}}->{{G96_Down}}
{{G96_Down}}->{{G59_UP, G72_UP}}
{{G59_UP}}->{{G72_UP, G96_Down}}
{{G72_UP}}->{{G59_UP, G96_Down}}

```

Number of rules generated from query(RULE HAS ANY OF G1\_UP, G6\_UP, G72\_UP) : 50

```

{{G72_UP}}->{{G32_Down}}
{{G32_Down}}->{{G72_UP}}
{{G6_UP}}->{{G38_Down}}
{{G38_Down}}->{{G6_UP}}
{{G6_UP}}->{{G28_Down}}
{{G28_Down}}->{{G6_UP}}
{{G97_Down}}->{{G72_UP}}
{{G72_UP}}->{{G97_Down}}
{{G67_UP}}->{{G1_UP}}
{{G1_UP}}->{{G67_UP}}
{{G6_UP}}->{{G59_UP}}
{{G59_UP}}->{{G6_UP}}
{{G72_UP}}->{{G1_UP}}
{{G1_UP}}->{{G72_UP}}
{{G72_UP}}->{{G13_Down}}
{{G13_Down}}->{{G72_UP}}
{{G72_UP}}->{{G38_Down}}
{{G38_Down}}->{{G72_UP}}
{{G82_Down}}->{{G72_UP}}
{{G72_UP}}->{{G82_Down}}
{{G6_UP}}->{{G32_Down}}
{{G32_Down}}->{{G6_UP}}
{{G54_UP}}->{{G1_UP}}
{{G1_UP}}->{{G54_UP}}
{{G96_Down}}->{{G72_UP}}
{{G72_UP}}->{{G96_Down}}
{{G72_UP}}->{{G59_UP}}
{{G59_UP}}->{{G72_UP}}

```

```

{[G70_Down]}->{[G1_UP]}
{[G1_UP]}->{[G70_Down]}
{[G59_UP]}->{[G1_UP]}
{[G1_UP]}->{[G59_UP]}
{[G38_Down]}->{[G1_UP]}
{[G1_UP]}->{[G38_Down]}
{[G1_UP]}->{[G10_Down]}
{[G10_Down]}->{[G1_UP]}
{[G6_UP]}->{[G13_Down]}
{[G13_Down]}->{[G6_UP]}
{[G72_UP, G82_Down]}->{[G59_UP]}
{[G59_UP, G82_Down]}->{[G72_UP]}
{[G59_UP, G72_UP]}->{[G82_Down]}
{[G82_Down]}->{[G59_UP, G72_UP]}
{[G59_UP]}->{[G72_UP, G82_Down]}
{[G72_UP]}->{[G59_UP, G82_Down]}
{[G72_UP, G96_Down]}->{[G59_UP]}
{[G59_UP, G96_Down]}->{[G72_UP]}
{[G59_UP, G72_UP]}->{[G96_Down]}
{[G96_Down]}->{[G59_UP, G72_UP]}
{[G59_UP]}->{[G72_UP, G96_Down]}
{[G72_UP]}->{[G59_UP, G96_Down]}

```

Number of rules generated from query(SIZE OF RULE>=3) : 12

```

{[G72_UP, G82_Down]}->{[G59_UP]}
{[G59_UP, G82_Down]}->{[G72_UP]}
{[G59_UP, G72_UP]}->{[G82_Down]}
{[G82_Down]}->{[G59_UP, G72_UP]}
{[G59_UP]}->{[G72_UP, G82_Down]}
{[G72_UP]}->{[G59_UP, G82_Down]}
{[G72_UP, G96_Down]}->{[G59_UP]}
{[G59_UP, G96_Down]}->{[G72_UP]}
{[G59_UP, G72_UP]}->{[G96_Down]}
{[G96_Down]}->{[G59_UP, G72_UP]}
{[G59_UP]}->{[G72_UP, G96_Down]}
{[G72_UP]}->{[G59_UP, G96_Down]}

```

Number of rules generated from query(SIZE OF BODY>=2) : 6

```

{[G72_UP, G82_Down]}->{[G59_UP]}
{[G59_UP, G82_Down]}->{[G72_UP]}
{[G59_UP, G72_UP]}->{[G82_Down]}
{[G82_Down]}->{[G59_UP, G72_UP]}
{[G59_UP]}->{[G72_UP, G82_Down]}
{[G72_UP]}->{[G59_UP, G82_Down]}
{[G72_UP, G96_Down]}->{[G59_UP]}
{[G59_UP, G96_Down]}->{[G72_UP]}
{[G59_UP, G72_UP]}->{[G96_Down]}
{[G96_Down]}->{[G59_UP, G72_UP]}
{[G59_UP]}->{[G72_UP, G96_Down]}
{[G72_UP]}->{[G59_UP, G96_Down]}

```

Number of rules generated from query(SIZE OF HEAD>=2) : 6

```

{[G82_Down]}->{[G59_UP, G72_UP]}
{[G59_UP]}->{[G72_UP, G82_Down]}
{[G72_UP]}->{[G59_UP, G82_Down]}
{[G96_Down]}->{[G59_UP, G72_UP]}
{[G59_UP]}->{[G72_UP, G96_Down]}
{[G72_UP]}->{[G59_UP, G96_Down]}

```

Number of rules generated from query(BODY HAS ANY OF G1\_UP AND HEAD HAS 1 OF G59\_UP) : 1

Number of rules generated from query(BODY HAS ANY OF G1\_UP OR HEAD HAS 1 OF G6\_UP) : 12

Number of rules generated from query(BODY HAS 1 OF G1\_UP OR HEAD HAS 2 OF G6\_UP) : 7

Number of rules generated from query(HEAD HAS 1 OF G1\_UP AND BODY HAS 0 OF DISEASE) : 7

Number of rules generated from query(HEAD HAS 1 OF DISEASE OR RULE HAS 1 OF (G72\_UP, G96\_DOWN)) : 24

Number of rules generated from query(BODY HAS 1 of (G59\_UP, G96\_DOWN) AND SIZE OF RULE  $\geq 3$ ) : 7