

Part-2

Apriori Algorithm:

The basic idea here is to take all the itemsets available in our data. These itemsets become our candidates for further operations. We use Apriori principle to reduce the number of candidates in the iterations. The principle is that if one itemset is frequent, then all the subsets following this itemset should be frequent too. We extend it to another property called anti-monotone property which says that if an itemset is infrequent, then all its supersets will be infrequent too. Hence, we don't have to generate all the supersets of an itemset which is found to be infrequent. With this principle, we filter the amount of operations we need to perform to generate the frequent itemset list by a great number by eliminating all the possible infrequent itemsets beforehand.

Let's take an example mentioned in the slides to explain the same:

Let us consider a list of items A, B, C, D, E. We calculate the frequency of each of these items from our data (by calculating the support and checking if the support is at least the minimum threshold support value). If A is found to be infrequent, we eliminate all the possible supersets of A i.e. AB, ABC, ABD, ABE, ABCD, ABCE, ABDE, ABCDE. Now we are left with only the supersets of B, C, D, E and we'll iteratively calculate the frequencies of each of these supersets and prune the infrequent supersets accordingly. We store these frequent itemsets according to their lengths for rule generation which is explained in the next section.

In our project, we are given data about patient's gene types and the type of disease. There are 100 genes which have binary attributes 'Up' and 'Down' and 4 common diseases among all. Now we use the same Apriori algorithm to generate frequent itemsets for this dataset. We check the frequency of all these attributes and store the frequent ones and discard the infrequent ones. We'll then merge all possible two attributes and generate the frequent itemsets in similar fashion. We continue this until we can't generate anymore length of frequent itemsets. It means that we can't have any bigger itemset which can be frequent. This concludes our Apriori algorithm.

Rule Generation:

We'll have our frequent itemsets ready by the time we start the rule generation. Just like we used support for generating the frequent itemsets, we use confidence to generate the rules. Rule generation is done by merging two rules which share a common prefix. A rule consists of a body and head as shown in the below example

Rule: $AB \rightarrow C$

Let's take an example mentioned in the slides to explain the same:

Let us consider a list of items A, B, C, D, E.

We have our frequent itemsets running after running Apriori and we'll use them here for our rule generation to reduce the number of operations.

We'll start with a head of length-1. Let's say we have got four rules $B,C,D \rightarrow A$; $A,C,D \rightarrow B$; $A,B,D \rightarrow C$; $A,B,C \rightarrow D$. We calculate the confidence for each of these rules and filter the rules which have confidence less than the threshold confidence. Now, if we find a low confidence rule, we can easily eliminate all the subsets of that rule as those rules will have low confidence as well. Let's say $B,C,D \rightarrow A$ has confidence less than threshold. Now all its subsets $C,D \rightarrow A,B$; $B,D \rightarrow A,C$; $B, C \rightarrow A,D$; $D \rightarrow A,B,C$; $C \rightarrow A,B,D$; $B \rightarrow A,C,D$ will be eliminated and the rest of the set will be used. In this way, we reduce the number of operations required to generate all the rules.

In our project, we initially start with frequent itemsets by considering a length of 1 in the head. We calculate the confidence of each itemset, prune the low-confidence itemsets and find subsets of the others and iterate it till we can. This concludes our rule generation. We store the frequent itemsets for querying purposes.

Results:

For Apriori Algorithm:

Support is set to be 30%

number of length-1 frequent itemsets: 196

number of length-2 frequent itemsets: 5340

number of length-3 frequent itemsets: 5287

number of length-4 frequent itemsets: 1518

number of length-5 frequent itemsets: 438

number of length-6 frequent itemsets: 88

number of length-7 frequent itemsets: 11

number of length-8 frequent itemsets: 1

number of length-9 frequent itemsets: 0

Support is set to be 40%

number of length-1 frequent itemsets: 167

number of length-2 frequent itemsets: 753

number of length-3 frequent itemsets: 149

number of length-4 frequent itemsets: 7

number of length-5 frequent itemsets: 1

number of length-6 frequent itemsets: 0

Support is set to be 50%

number of length-1 frequent itemsets: 109

number of length-2 frequent itemsets: 63

number of length-3 frequent itemsets: 2

number of length-4 frequent itemsets: 0

Support is set to be 60%

number of length-1 frequent itemsets: 34

number of length-2 frequent itemsets: 2

number of length-3 frequent itemsets: 0

Support is set to be 70%

number of length-1 frequent itemsets: 7

number of length-2 frequent itemsets: 0

For Rule Generation:

Template-1

Query -(result11, cnt) = asso_rule.template1("RULE", "ANY", ['G59_Up'])
: [{ 'G59_Up,G72_Up': 'G82_Down'}, { 'G59_Up,G82_Down': 'G72_Up'}, { 'G72_Up, G82_Down': 'G59_Up'}, { 'G72_Up': 'G82_Down,G59_Up'}, { 'G82_Down': 'G72_Up, G59_Up'}, { 'G59_Up,G72_Up': 'G96_Down'}, { 'G59_Up,G96_Down': 'G72_Up'}, { 'G72_Up,G96_Down': 'G59_Up'}, { 'G96_Down': 'G72_Up,G59_Up'}, { 'G01_Up': 'G59_Up'}, { 'G06_Up': 'G59_Up'}, { 'G59_Up': 'G13_Down'}, { 'G13_Down': 'G59_Up'}, { 'G28_Down': 'G59_Up'}, { 'G72_Up': 'G59_Up'}, { 'G59_Up': 'G72_Up'}, { 'G82_Down': 'G59_Up'}, { 'G59_Up': 'G82_Down'}, { 'G96_Down': 'G59_Up'}, { 'G59_Up': 'G96_Down'}, { 'G38_Down': 'G59_Up'}, { 'G87_Up': 'G59_Up'}, { 'G88_Down': 'G59_Up'}, { 'G59_Up': 'G88_Down'}, { 'G32_Down': 'G59_Up'}, { 'G10_Down': 'G59_Up'}] and length is 26

Query - (result12, cnt) = asso_rule.template1("RULE", "NONE", ['G59_Up'])
: [{ 'G72_Up': 'G01_Up'}, { 'G01_Up': 'G72_Up'}, { 'G13_Down': 'G06_Up'}, { 'G06_Up': 'G13_Down'}, { 'G28_Down': 'G06_Up'}, { 'G06_Up': 'G28_Down'}, { 'G28_Down': 'G13_Down'}, { 'G13_Down': 'G28_Down'}, { 'G72_Up': 'G13_Down'}, { 'G13_Down': 'G72_Up'}, { 'G82_Down': 'G13_Down'}, { 'G13_Down': 'G82_Down'}, { 'G52_Down': 'G28_Down'}, { 'G28_Down': 'G52_Down'}, { 'G82_Down': 'G72_Up'}, { 'G72_Up': 'G82_Down'}, { 'G96_Down': 'G72_Up'}, { 'G72_Up': 'G96_Down'}, { 'G97_Down': 'G72_Up'}, { 'G96_Down': 'G82_Down'}, { 'G82_Down': 'G96_Down'}, { 'G97_Down': 'G82_Down'}, { 'G82_Down': 'G97_Down'}, { 'G38_Down': 'G01_Up'}, { 'G01_Up': 'G38_Down'}, { 'G54_Up': 'G01_Up'}, { 'G01_Up': 'G54_Up'}, { 'G02_Down': 'G38_Down'}, { 'G47_Up': 'G38_Down'}, { 'G38_Down': 'G47_Up'}, { 'G52_Down': 'G38_Down'}, { 'G38_Down': 'G52_Down'}, { 'G65_Down': 'G38_Down'}, { 'G88_Down': 'G38_Down'}, { 'G88_Down': 'G54_Up'}, { 'G54_Up': 'G88_Down'}, { 'G88_Down': 'G87_Up'}, { 'G87_Up': 'G88_Down'}, { 'G28_Down': 'G02_Down'}, { 'G02_Down': 'G28_Down'}, { 'G32_Down': 'G06_Up'}, { 'G06_Up': 'G32_Down'}, { 'G54_Up': 'G24_Down'}, { 'G24_Down': 'G54_Up'}, { 'G32_Down': 'G28_Down'}, { 'G28_Down': 'G32_Down'}, { 'G87_Up': 'G87_Up'}]

G28_Down'}, {'G28_Down': 'G87_Up'}, {'G32_Down': 'G72_Up'}, {'G38_Down': 'G28_Down'}, {'G28_Down': 'G38_Down'}, {'G47_Up': 'G28_Down'}, {'G28_Down': 'G47_Up'}, {'G38_Down': 'G32_Down'}, {'G32_Down': 'G38_Down'}, {'G91_Up': 'G38_Down'}, {'G38_Down': 'G91_Up'}, {'G94_Up': 'G38_Down'}, {'G10_Down': 'G01_Up'}, {'G01_Up': 'G10_Down'}, {'G70_Down': 'G01_Up'}, {'G01_Up': 'G70_Down'}, {'G88_Down': 'G08_Up'}, {'G08_Up': 'G88_Down'}, {'G28_Down': 'G10_Down'}, {'G10_Down': 'G28_Down'}, {'G47_Up': 'G10_Down'}, {'G10_Down': 'G47_Up'}, {'G70_Down': 'G10_Down'}, {'G10_Down': 'G70_Down'}, {'G88_Down': 'G10_Down'}, {'G10_Down': 'G88_Down'}, {'G88_Down': 'G24_Down'}, {'G24_Down': 'G88_Down'}, {'G41_Down': 'G28_Down'}, {'G28_Down': 'G41_Down'}, {'G88_Down': 'G28_Down'}, {'G28_Down': 'G88_Down'}, {'G88_Down': 'G41_Down'}, {'G41_Down': 'G88_Down'}, {'G67_Up': 'G01_Up'}, {'G01_Up': 'G67_Up'}, {'G06_Up': 'G38_Down'}, {'G38_Down': 'G10_Down'}, {'G10_Down': 'G38_Down'}, {'G94_Up': 'G10_Down'}, {'G10_Down': 'G94_Up'}, {'G41_Down': 'G38_Down'}, {'G67_Up': 'G38_Down'}, {'G70_Down': 'G38_Down'}, {'G38_Down': 'G70_Down'}}]and length is 91

Query - (result13, cnt) = asso_rule.template1("RULE", 1, ['G59_Up', 'G10_Down']) : [{'G59_Up,G72_Up': 'G82_Down'}, {'G59_Up,G82_Down': 'G72_Up'}, {'G72_Up,G82_Down': 'G59_Up'}, {'G72_Up': 'G82_Down,G59_Up'}, {'G82_Down': 'G72_Up,G59_Up'}, {'G59_Up,G72_Up': 'G96_Down'}, {'G59_Up,G96_Down': 'G72_Up'}, {'G72_Up,G96_Down': 'G59_Up'}, {'G96_Down': 'G72_Up,G59_Up'}, {'G01_Up': 'G59_Up'}, {'G06_Up': 'G59_Up'}, {'G59_Up': 'G13_Down'}, {'G13_Down': 'G59_Up'}, {'G28_Down': 'G59_Up'}, {'G72_Up': 'G59_Up'}, {'G59_Up': 'G72_Up'}, {'G82_Down': 'G59_Up'}, {'G59_Up': 'G82_Down'}, {'G96_Down': 'G59_Up'}, {'G59_Up': 'G96_Down'}, {'G38_Down': 'G59_Up'}, {'G87_Up': 'G59_Up'}, {'G88_Down': 'G59_Up'}, {'G59_Up': 'G88_Down'}, {'G32_Down': 'G59_Up'}, {'G10_Down': 'G01_Up'}, {'G01_Up': 'G10_Down'}, {'G28_Down': 'G10_Down'}, {'G10_Down': 'G28_Down'}, {'G47_Up': 'G10_Down'}, {'G10_Down': 'G47_Up'}, {'G70_Down': 'G10_Down'}, {'G10_Down': 'G70_Down'}, {'G88_Down': 'G10_Down'}, {'G10_Down': 'G88_Down'}, {'G38_Down': 'G10_Down'}, {'G10_Down': 'G38_Down'}, {'G94_Up': 'G10_Down'}, {'G10_Down': 'G94_Up'}]and length is 39

Query - (result14, cnt) = asso_rule.template1("BODY", "ANY", ['G59_Up']) : [{'G59_Up,G72_Up': 'G82_Down'}, {'G59_Up,G82_Down': 'G72_Up'}, {'G59_Up,G72_Up': 'G96_Down'}, {'G59_Up,G96_Down': 'G72_Up'}, {'G59_Up': 'G13_Down'}, {'G59_Up': 'G72_Up'}, {'G59_Up': 'G82_Down'}, {'G59_Up': 'G96_Down'}, {'G59_Up': 'G88_Down'}]and length is 9

Query - (result15, cnt) = asso_rule.template1("BODY", "NONE", ['G59_Up'])
: [{'G72_Up,G82_Down': 'G59_Up'}, {'G72_Up': 'G82_Down,G59_Up'}, {'G82_Dow
n': 'G72_Up,G59_Up'}, {'G72_Up,G96_Down': 'G59_Up'}, {'G96_Down': 'G72_Up,G
59_Up'}, {'G01_Up': 'G59_Up'}, {'G72_Up': 'G01_Up'}, {'G01_Up': 'G72_Up'}, {'G13
_Down': 'G06_Up'}, {'G06_Up': 'G13_Down'}, {'G28_Down': 'G06_Up'}, {'G06_Up':
'G28_Down'}, {'G06_Up': 'G59_Up'}, {'G28_Down': 'G13_Down'}, {'G13_Down': 'G
28_Down'}, {'G13_Down': 'G59_Up'}, {'G72_Up': 'G13_Down'}, {'G13_Down': 'G72
_Up'}, {'G82_Down': 'G13_Down'}, {'G13_Down': 'G82_Down'}, {'G52_Down': 'G28
_Down'}, {'G28_Down': 'G52_Down'}, {'G28_Down': 'G59_Up'}, {'G72_Up': 'G59_U
p'}, {'G82_Down': 'G59_Up'}, {'G96_Down': 'G59_Up'}, {'G82_Down': 'G72_Up'}, {'
G72_Up': 'G82_Down'}, {'G96_Down': 'G72_Up'}, {'G72_Up': 'G96_Down'}, {'G97_
Down': 'G72_Up'}, {'G96_Down': 'G82_Down'}, {'G82_Down': 'G96_Down'}, {'G97_
Down': 'G82_Down'}, {'G82_Down': 'G97_Down'}, {'G38_Down': 'G01_Up'}, {'G01_
Up': 'G38_Down'}, {'G54_Up': 'G01_Up'}, {'G01_Up': 'G54_Up'}, {'G02_Down': 'G3
8_Down'}, {'G47_Up': 'G38_Down'}, {'G38_Down': 'G47_Up'}, {'G52_Down': 'G38_
Down'}, {'G38_Down': 'G52_Down'}, {'G38_Down': 'G59_Up'}, {'G65_Down': 'G38_
Down'}, {'G88_Down': 'G38_Down'}, {'G88_Down': 'G54_Up'}, {'G54_Up': 'G88_Do
wn'}, {'G87_Up': 'G59_Up'}, {'G88_Down': 'G59_Up'}, {'G88_Down': 'G87_Up'}, {'G
87_Up': 'G88_Down'}, {'G28_Down': 'G02_Down'}, {'G02_Down': 'G28_Down'}, {'G
32_Down': 'G06_Up'}, {'G06_Up': 'G32_Down'}, {'G54_Up': 'G24_Down'}, {'G24_D
own': 'G54_Up'}, {'G32_Down': 'G28_Down'}, {'G28_Down': 'G32_Down'}, {'G87_U
p': 'G28_Down'}, {'G28_Down': 'G87_Up'}, {'G32_Down': 'G59_Up'}, {'G32_Down':
'G72_Up'}, {'G38_Down': 'G28_Down'}, {'G28_Down': 'G38_Down'}, {'G47_Up': 'G
28_Down'}, {'G28_Down': 'G47_Up'}, {'G38_Down': 'G32_Down'}, {'G32_Down': 'G
38_Down'}, {'G91_Up': 'G38_Down'}, {'G38_Down': 'G91_Up'}, {'G94_Up': 'G38_D
own'}, {'G10_Down': 'G01_Up'}, {'G01_Up': 'G10_Down'}, {'G70_Down': 'G01_Up'
, {'G01_Up': 'G70_Down'}, {'G88_Down': 'G08_Up'}, {'G08_Up': 'G88_Down'}, {'G2
8_Down': 'G10_Down'}, {'G10_Down': 'G28_Down'}, {'G47_Up': 'G10_Down'}, {'G1
0_Down': 'G47_Up'}, {'G10_Down': 'G59_Up'}, {'G70_Down': 'G10_Down'}, {'G10_
Down': 'G70_Down'}, {'G88_Down': 'G10_Down'}, {'G10_Down': 'G88_Down'}, {'G
88_Down': 'G24_Down'}, {'G24_Down': 'G88_Down'}, {'G41_Down': 'G28_Down'},
{'G28_Down': 'G41_Down'}, {'G88_Down': 'G28_Down'}, {'G28_Down': 'G88_Dow
n'}, {'G88_Down': 'G41_Down'}, {'G41_Down': 'G88_Down'}, {'G67_Up': 'G01_Up'
, {'G01_Up': 'G67_Up'}, {'G06_Up': 'G38_Down'}, {'G38_Down': 'G10_Down'}, {'G1
0_Down': 'G38_Down'}, {'G94_Up': 'G10_Down'}, {'G10_Down': 'G94_Up'}, {'G41_

Down': 'G38_Down'}, {'G67_Up': 'G38_Down'}, {'G70_Down': 'G38_Down'}, {'G38_Down': 'G70_Down'}}]and length is 108

Query - (result16, cnt) = asso_rule.template1("BODY", 1, ['G59_Up', 'G10_Down'])
: [{'G59_Up,G72_Up': 'G82_Down'}, {'G59_Up,G82_Down': 'G72_Up'}, {'G59_Up,
G72_Up': 'G96_Down'}, {'G59_Up,G96_Down': 'G72_Up'}, {'G59_Up': 'G13_Down'
}, {'G59_Up': 'G72_Up'}, {'G59_Up': 'G82_Down'}, {'G59_Up': 'G96_Down'}, {'G59_
Up': 'G88_Down'}, {'G10_Down': 'G01_Up'}, {'G10_Down': 'G28_Down'}, {'G10_Do
wn': 'G47_Up'}, {'G10_Down': 'G59_Up'}, {'G10_Down': 'G70_Down'}, {'G10_Down
': 'G88_Down'}, {'G10_Down': 'G38_Down'}, {'G10_Down': 'G94_Up'}]]and length is
17

Query - (result17, cnt) = asso_rule.template1("HEAD", "ANY", ['G59_Up'])
: [{'G72_Up,G82_Down': 'G59_Up'}, {'G72_Up': 'G82_Down,G59_Up'}, {'G82_Dow
n': 'G72_Up,G59_Up'}, {'G72_Up,G96_Down': 'G59_Up'}, {'G96_Down': 'G72_Up,G
59_Up'}, {'G01_Up': 'G59_Up'}, {'G06_Up': 'G59_Up'}, {'G13_Down': 'G59_Up'}, {'G
28_Down': 'G59_Up'}, {'G72_Up': 'G59_Up'}, {'G82_Down': 'G59_Up'}, {'G96_Dow
n': 'G59_Up'}, {'G38_Down': 'G59_Up'}, {'G87_Up': 'G59_Up'}, {'G88_Down': 'G59_
Up'}, {'G32_Down': 'G59_Up'}, {'G10_Down': 'G59_Up'}]]and length is 17

Query - (result18, cnt) = asso_rule.template1("HEAD", "NONE", ['G59_Up'])
: [{'G59_Up,G72_Up': 'G82_Down'}, {'G59_Up,G82_Down': 'G72_Up'}, {'G59_Up,
G72_Up': 'G96_Down'}, {'G59_Up,G96_Down': 'G72_Up'}, {'G72_Up': 'G01_Up'}, {'
G01_Up': 'G72_Up'}, {'G13_Down': 'G06_Up'}, {'G06_Up': 'G13_Down'}, {'G28_Do
wn': 'G06_Up'}, {'G06_Up': 'G28_Down'}, {'G28_Down': 'G13_Down'}, {'G13_Down
': 'G28_Down'}, {'G59_Up': 'G13_Down'}, {'G72_Up': 'G13_Down'}, {'G13_Down': '
G72_Up'}, {'G82_Down': 'G13_Down'}, {'G13_Down': 'G82_Down'}, {'G52_Down': '
G28_Down'}, {'G28_Down': 'G52_Down'}, {'G59_Up': 'G72_Up'}, {'G59_Up': 'G82_
Down'}, {'G59_Up': 'G96_Down'}, {'G82_Down': 'G72_Up'}, {'G72_Up': 'G82_Down
'}, {'G96_Down': 'G72_Up'}, {'G72_Up': 'G96_Down'}, {'G97_Down': 'G72_Up'}, {'G
96_Down': 'G82_Down'}, {'G82_Down': 'G96_Down'}, {'G97_Down': 'G82_Down'},
{'G82_Down': 'G97_Down'}, {'G38_Down': 'G01_Up'}, {'G01_Up': 'G38_Down'}, {'G
54_Up': 'G01_Up'}, {'G01_Up': 'G54_Up'}, {'G02_Down': 'G38_Down'}, {'G47_Up': '
G38_Down'}, {'G38_Down': 'G47_Up'}, {'G52_Down': 'G38_Down'}, {'G38_Down': '
G52_Down'}, {'G65_Down': 'G38_Down'}, {'G88_Down': 'G38_Down'}, {'G88_Dow
n': 'G54_Up'}, {'G54_Up': 'G88_Down'}, {'G59_Up': 'G88_Down'}, {'G88_Down': 'G
87_Up'}, {'G87_Up': 'G88_Down'}, {'G28_Down': 'G02_Down'}, {'G02_Down': 'G28

_Down'}, {'G32_Down': 'G06_Up'}, {'G06_Up': 'G32_Down'}, {'G54_Up': 'G24_Down'}, {'G24_Down': 'G54_Up'}, {'G32_Down': 'G28_Down'}, {'G28_Down': 'G32_Down'}, {'G87_Up': 'G28_Down'}, {'G28_Down': 'G87_Up'}, {'G32_Down': 'G72_Up'}, {'G38_Down': 'G28_Down'}, {'G28_Down': 'G38_Down'}, {'G47_Up': 'G28_Down'}, {'G28_Down': 'G47_Up'}, {'G38_Down': 'G32_Down'}, {'G32_Down': 'G38_Down'}, {'G91_Up': 'G38_Down'}, {'G38_Down': 'G91_Up'}, {'G94_Up': 'G38_Down'}, {'G10_Down': 'G01_Up'}, {'G01_Up': 'G10_Down'}, {'G70_Down': 'G01_Up'}, {'G01_Up': 'G70_Down'}, {'G88_Down': 'G08_Up'}, {'G08_Up': 'G88_Down'}, {'G28_Down': 'G10_Down'}, {'G10_Down': 'G28_Down'}, {'G47_Up': 'G10_Down'}, {'G10_Down': 'G47_Up'}, {'G70_Down': 'G10_Down'}, {'G10_Down': 'G70_Down'}, {'G88_Down': 'G10_Down'}, {'G10_Down': 'G88_Down'}, {'G88_Down': 'G24_Down'}, {'G24_Down': 'G88_Down'}, {'G41_Down': 'G28_Down'}, {'G28_Down': 'G41_Down'}, {'G88_Down': 'G28_Down'}, {'G28_Down': 'G88_Down'}, {'G88_Down': 'G41_Down'}, {'G41_Down': 'G88_Down'}, {'G67_Up': 'G01_Up'}, {'G01_Up': 'G67_Up'}, {'G06_Up': 'G38_Down'}, {'G38_Down': 'G10_Down'}, {'G10_Down': 'G38_Down'}, {'G94_Up': 'G10_Down'}, {'G10_Down': 'G94_Up'}, {'G41_Down': 'G38_Down'}, {'G67_Up': 'G38_Down'}, {'G70_Down': 'G38_Down'}, {'G38_Down': 'G70_Down'}]and length is 100

Query - (result19, cnt) = asso_rule.template1("HEAD", 1, ['G59_Up', 'G10_Down']) : [{'G72_Up,G82_Down': 'G59_Up'}, {'G72_Up': 'G82_Down,G59_Up'}, {'G82_Down': 'G72_Up,G59_Up'}, {'G72_Up,G96_Down': 'G59_Up'}, {'G96_Down': 'G72_Up,G59_Up'}, {'G01_Up': 'G59_Up'}, {'G06_Up': 'G59_Up'}, {'G13_Down': 'G59_Up'}, {'G28_Down': 'G59_Up'}, {'G72_Up': 'G59_Up'}, {'G82_Down': 'G59_Up'}, {'G96_Down': 'G59_Up'}, {'G38_Down': 'G59_Up'}, {'G87_Up': 'G59_Up'}, {'G88_Down': 'G59_Up'}, {'G32_Down': 'G59_Up'}, {'G01_Up': 'G10_Down'}, {'G28_Down': 'G10_Down'}, {'G47_Up': 'G10_Down'}, {'G10_Down': 'G59_Up'}, {'G70_Down': 'G10_Down'}, {'G88_Down': 'G10_Down'}, {'G38_Down': 'G10_Down'}, {'G94_Up': 'G10_Down'}] and length is 24

Template-2:

Query - (result21, cnt) = asso_rule.template2("RULE", 3) : [{'G59_Up,G72_Up': 'G82_Down'}, {'G59_Up,G82_Down': 'G72_Up'}, {'G72_Up,G82_Down': 'G59_Up'}, {'G72_Up': 'G82_Down,G59_Up'}, {'G82_Down': 'G72_Up,G59_Up'}, {'G59_Up,G72_Up': 'G96_Down'}, {'G59_Up,G96_Down': 'G72_Up'}, {'G72_Up,G96_Down': 'G59_Up'}, {'G96_Down': 'G72_Up,G59_Up'}]and length is 9

Query - (result22, cnt) = asso_rule.template2("BODY", 2)
: [{ 'G59_Up,G72_Up': 'G82_Down'}, { 'G59_Up,G82_Down': 'G72_Up'}, { 'G72_Up,
G82_Down': 'G59_Up'}, { 'G59_Up,G72_Up': 'G96_Down'}, { 'G59_Up,G96_Down': '
G72_Up'}, { 'G72_Up,G96_Down': 'G59_Up'}]and length is 6

Query - (result23, cnt) = asso_rule.template2("HEAD", 1) : [{ 'G59_Up,G72_Up': 'G
82_Down'}, { 'G59_Up,G82_Down': 'G72_Up'}, { 'G72_Up,G82_Down': 'G59_Up'}, { '
G72_Up': 'G82_Down,G59_Up'}, { 'G82_Down': 'G72_Up,G59_Up'}, { 'G59_Up,G72
_Up': 'G96_Down'}, { 'G59_Up,G96_Down': 'G72_Up'}, { 'G72_Up,G96_Down': 'G59
_Up'}, { 'G96_Down': 'G72_Up,G59_Up'}, { 'G01_Up': 'G59_Up'}, { 'G72_Up': 'G01_U
p'}, { 'G01_Up': 'G72_Up'}, { 'G13_Down': 'G06_Up'}, { 'G06_Up': 'G13_Down'}, { 'G2
8_Down': 'G06_Up'}, { 'G06_Up': 'G28_Down'}, { 'G06_Up': 'G59_Up'}, { 'G28_Down'
: 'G13_Down'}, { 'G13_Down': 'G28_Down'}, { 'G59_Up': 'G13_Down'}, { 'G13_Down'
: 'G59_Up'}, { 'G72_Up': 'G13_Down'}, { 'G13_Down': 'G72_Up'}, { 'G82_Down': 'G13
_Down'}, { 'G13_Down': 'G82_Down'}, { 'G52_Down': 'G28_Down'}, { 'G28_Down': '
G52_Down'}, { 'G28_Down': 'G59_Up'}, { 'G72_Up': 'G59_Up'}, { 'G59_Up': 'G72_Up'
}, { 'G82_Down': 'G59_Up'}, { 'G59_Up': 'G82_Down'}, { 'G96_Down': 'G59_Up'}, { 'G5
9_Up': 'G96_Down'}, { 'G82_Down': 'G72_Up'}, { 'G72_Up': 'G82_Down'}, { 'G96_Do
wn': 'G72_Up'}, { 'G72_Up': 'G96_Down'}, { 'G97_Down': 'G72_Up'}, { 'G96_Down': '
G82_Down'}, { 'G82_Down': 'G96_Down'}, { 'G97_Down': 'G82_Down'}, { 'G82_Dow
n': 'G97_Down'}, { 'G38_Down': 'G01_Up'}, { 'G01_Up': 'G38_Down'}, { 'G54_Up': 'G
01_Up'}, { 'G01_Up': 'G54_Up'}, { 'G02_Down': 'G38_Down'}, { 'G47_Up': 'G38_Dow
n'}, { 'G38_Down': 'G47_Up'}, { 'G52_Down': 'G38_Down'}, { 'G38_Down': 'G52_Dow
n'}, { 'G38_Down': 'G59_Up'}, { 'G65_Down': 'G38_Down'}, { 'G88_Down': 'G38_Dow
n'}, { 'G88_Down': 'G54_Up'}, { 'G54_Up': 'G88_Down'}, { 'G87_Up': 'G59_Up'}, { 'G8
8_Down': 'G59_Up'}, { 'G59_Up': 'G88_Down'}, { 'G88_Down': 'G87_Up'}, { 'G87_Up'
: 'G88_Down'}, { 'G28_Down': 'G02_Down'}, { 'G02_Down': 'G28_Down'}, { 'G32_Do
wn': 'G06_Up'}, { 'G06_Up': 'G32_Down'}, { 'G54_Up': 'G24_Down'}, { 'G24_Down': '
G54_Up'}, { 'G32_Down': 'G28_Down'}, { 'G28_Down': 'G32_Down'}, { 'G87_Up': 'G2
8_Down'}, { 'G28_Down': 'G87_Up'}, { 'G32_Down': 'G59_Up'}, { 'G32_Down': 'G72_
Up'}, { 'G38_Down': 'G28_Down'}, { 'G28_Down': 'G38_Down'}, { 'G47_Up': 'G28_Do
wn'}, { 'G28_Down': 'G47_Up'}, { 'G38_Down': 'G32_Down'}, { 'G32_Down': 'G38_Do
wn'}, { 'G91_Up': 'G38_Down'}, { 'G38_Down': 'G91_Up'}, { 'G94_Up': 'G38_Down'},
{ 'G10_Down': 'G01_Up'}, { 'G01_Up': 'G10_Down'}, { 'G70_Down': 'G01_Up'}, { 'G01
_Up': 'G70_Down'}, { 'G88_Down': 'G08_Up'}, { 'G08_Up': 'G88_Down'}, { 'G28_Dow
n': 'G10_Down'}, { 'G10_Down': 'G28_Down'}, { 'G47_Up': 'G10_Down'}, { 'G10_Dow
n': 'G47_Up'}, { 'G10_Down': 'G59_Up'}, { 'G70_Down': 'G10_Down'}, { 'G10_Down':

'G70_Down'}, {'G88_Down': 'G10_Down'}, {'G10_Down': 'G88_Down'}, {'G88_Down': 'G24_Down'}, {'G24_Down': 'G88_Down'}, {'G41_Down': 'G28_Down'}, {'G28_Down': 'G41_Down'}, {'G88_Down': 'G28_Down'}, {'G28_Down': 'G88_Down'}, {'G88_Down': 'G41_Down'}, {'G41_Down': 'G88_Down'}, {'G67_Up': 'G01_Up'}, {'G01_Up': 'G67_Up'}, {'G06_Up': 'G38_Down'}, {'G38_Down': 'G10_Down'}, {'G10_Down': 'G38_Down'}, {'G94_Up': 'G10_Down'}, {'G10_Down': 'G94_Up'}, {'G41_Down': 'G38_Down'}, {'G67_Up': 'G38_Down'}, {'G70_Down': 'G38_Down'}, {'G38_Down': 'G70_Down'}}and length is 117

Template-3:

Query - (result31, cnt) = asso_rule.template3("1or1", "BODY", "ANY", ['G10_Down'], "HEAD", 1, ['G59_Up'])
: [{'G10_Down': 'G01_Up'}, {'G10_Down': 'G28_Down'}, {'G10_Down': 'G47_Up'}, {'G10_Down': 'G59_Up'}, {'G10_Down': 'G70_Down'}, {'G10_Down': 'G88_Down'}, {'G10_Down': 'G38_Down'}, {'G10_Down': 'G94_Up'}, {'G72_Up,G82_Down': 'G59_Up'}, {'G72_Up': 'G59_Up,G82_Down'}, {'G82_Down': 'G59_Up,G72_Up'}, {'G72_Up,G96_Down': 'G59_Up'}, {'G96_Down': 'G59_Up,G72_Up'}, {'G01_Up': 'G59_Up'}, {'G06_Up': 'G59_Up'}, {'G13_Down': 'G59_Up'}, {'G28_Down': 'G59_Up'}, {'G72_Up': 'G59_Up'}, {'G82_Down': 'G59_Up'}, {'G96_Down': 'G59_Up'}, {'G38_Down': 'G59_Up'}, {'G87_Up': 'G59_Up'}, {'G88_Down': 'G59_Up'}, {'G32_Down': 'G59_Up'}]and length is 24

Query - (result32, cnt) = asso_rule.template3("1and1", "BODY", "ANY", ['G10_Down'], "HEAD", 1, ['G59_Up'])
: [{'G10_Down': 'G59_Up'}]and length is 1

Query - (result33, cnt) = asso_rule.template3("1or2", "BODY", "ANY", ['G10_Down'], "HEAD", 2)
: [{'G10_Down': 'G01_Up'}, {'G10_Down': 'G28_Down'}, {'G10_Down': 'G47_Up'}, {'G10_Down': 'G59_Up'}, {'G10_Down': 'G70_Down'}, {'G10_Down': 'G88_Down'}, {'G10_Down': 'G38_Down'}, {'G10_Down': 'G94_Up'}, {'G72_Up': 'G59_Up,G82_Down'}, {'G82_Down': 'G59_Up,G72_Up'}, {'G96_Down': 'G59_Up,G72_Up'}]and length is 11

Query - (result34, cnt) = asso_rule.template3("1and2", "BODY", "ANY", ['G10_Down'], "HEAD", 2)

: []and length is 0

Query - (result35, cnt) = asso_rule.template3("2or2", "BODY", 1, "HEAD", 2)
: [{ 'G72_Up,G82_Down': 'G59_Up'}, { 'G59_Up,G72_Up': 'G82_Down'}, { 'G59_Up,
G82_Down': 'G72_Up'}, { 'G72_Up': 'G59_Up,G82_Down'}, { 'G82_Down': 'G59_Up,
G72_Up'}, { 'G72_Up,G96_Down': 'G59_Up'}, { 'G59_Up,G72_Up': 'G96_Down'}, { 'G
59_Up,G96_Down': 'G72_Up'}, { 'G96_Down': 'G59_Up,G72_Up'}, { 'G01_Up': 'G59
_Up'}, { 'G72_Up': 'G01_Up'}, { 'G01_Up': 'G72_Up'}, { 'G13_Down': 'G06_Up'}, { 'G06
_Up': 'G13_Down'}, { 'G28_Down': 'G06_Up'}, { 'G06_Up': 'G28_Down'}, { 'G06_Up':
'G59_Up'}, { 'G28_Down': 'G13_Down'}, { 'G13_Down': 'G28_Down'}, { 'G59_Up': 'G
13_Down'}, { 'G13_Down': 'G59_Up'}, { 'G72_Up': 'G13_Down'}, { 'G13_Down': 'G72
_Up'}, { 'G82_Down': 'G13_Down'}, { 'G13_Down': 'G82_Down'}, { 'G52_Down': 'G28
_Down'}, { 'G28_Down': 'G52_Down'}, { 'G28_Down': 'G59_Up'}, { 'G72_Up': 'G59_U
p'}, { 'G59_Up': 'G72_Up'}, { 'G82_Down': 'G59_Up'}, { 'G59_Up': 'G82_Down'}, { 'G9
6_Down': 'G59_Up'}, { 'G59_Up': 'G96_Down'}, { 'G82_Down': 'G72_Up'}, { 'G72_Up'
: 'G82_Down'}, { 'G96_Down': 'G72_Up'}, { 'G72_Up': 'G96_Down'}, { 'G97_Down': '
G72_Up'}, { 'G96_Down': 'G82_Down'}, { 'G82_Down': 'G96_Down'}, { 'G97_Down': '
G82_Down'}, { 'G82_Down': 'G97_Down'}, { 'G38_Down': 'G01_Up'}, { 'G01_Up': 'G3
8_Down'}, { 'G54_Up': 'G01_Up'}, { 'G01_Up': 'G54_Up'}, { 'G02_Down': 'G38_Down'
}, { 'G47_Up': 'G38_Down'}, { 'G38_Down': 'G47_Up'}, { 'G52_Down': 'G38_Down'}, {
'G38_Down': 'G52_Down'}, { 'G38_Down': 'G59_Up'}, { 'G65_Down': 'G38_Down'}, {
'G88_Down': 'G38_Down'}, { 'G88_Down': 'G54_Up'}, { 'G54_Up': 'G88_Down'}, { 'G
87_Up': 'G59_Up'}, { 'G88_Down': 'G59_Up'}, { 'G59_Up': 'G88_Down'}, { 'G88_Dow
n': 'G87_Up'}, { 'G87_Up': 'G88_Down'}, { 'G28_Down': 'G02_Down'}, { 'G02_Down':
'G28_Down'}, { 'G32_Down': 'G06_Up'}, { 'G06_Up': 'G32_Down'}, { 'G54_Up': 'G24_
Down'}, { 'G24_Down': 'G54_Up'}, { 'G32_Down': 'G28_Down'}, { 'G28_Down': 'G32_
Down'}, { 'G87_Up': 'G28_Down'}, { 'G28_Down': 'G87_Up'}, { 'G32_Down': 'G59_Up
'}, { 'G32_Down': 'G72_Up'}, { 'G38_Down': 'G28_Down'}, { 'G28_Down': 'G38_Down
'}, { 'G47_Up': 'G28_Down'}, { 'G28_Down': 'G47_Up'}, { 'G38_Down': 'G32_Down'},
{ 'G32_Down': 'G38_Down'}, { 'G91_Up': 'G38_Down'}, { 'G38_Down': 'G91_Up'}, { 'G
94_Up': 'G38_Down'}, { 'G10_Down': 'G01_Up'}, { 'G01_Up': 'G10_Down'}, { 'G70_D
own': 'G01_Up'}, { 'G01_Up': 'G70_Down'}, { 'G88_Down': 'G08_Up'}, { 'G08_Up': 'G
88_Down'}, { 'G28_Down': 'G10_Down'}, { 'G10_Down': 'G28_Down'}, { 'G47_Up': 'G
10_Down'}, { 'G10_Down': 'G47_Up'}, { 'G10_Down': 'G59_Up'}, { 'G70_Down': 'G10
_Down'}, { 'G10_Down': 'G70_Down'}, { 'G88_Down': 'G10_Down'}, { 'G10_Down': '
G88_Down'}, { 'G88_Down': 'G24_Down'}, { 'G24_Down': 'G88_Down'}, { 'G41_Dow
n': 'G28_Down'}, { 'G28_Down': 'G41_Down'}, { 'G88_Down': 'G28_Down'}, { 'G28_D

own': 'G88_Down'}, {'G88_Down': 'G41_Down'}, {'G41_Down': 'G88_Down'}, {'G67_Up': 'G01_Up'}, {'G01_Up': 'G67_Up'}, {'G06_Up': 'G38_Down'}, {'G38_Down': 'G10_Down'}, {'G10_Down': 'G38_Down'}, {'G94_Up': 'G10_Down'}, {'G10_Down': 'G94_Up'}, {'G41_Down': 'G38_Down'}, {'G67_Up': 'G38_Down'}, {'G70_Down': 'G38_Down'}, {'G38_Down': 'G70_Down'}]]and length is 117

Query - (result36, cnt) = asso_rule.template3("2and2", "BODY", 1, "HEAD", 2) : [{'G72_Up': 'G59_Up,G82_Down'}, {'G82_Down': 'G59_Up,G72_Up'}, {'G96_Down': 'G59_Up,G72_Up'}]]and length is 3