

Apriori Algorithm report

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1 Apriori Implementation

Apriori Algorithm is used to mine the association rule to explore the relationship between each feature set. To implement apriori algorithm, it requires two major step. One is to generate the frequent item set out of entire transaction log. Another one is generate rule base on these frequent itemset which we found on the previous step. The following is the detail implementation of this algorithm.

1.1 Frequent itemset generation

The first step of apriori algorithm is to generate frequent itemset from the transaction log. With that, our team generate frequent itemset by increment the length of itemset and utilizes a technique to prune the candidate itemset in order to reduce the computation cost. Because as we proceed to longer itemset, the combination of the itemset grow super fast.

First, the program iterates through entire feature space to explore the length-1 frequent item. With frequent item meaning, the itemset exist at least minsupp portion of times out of entire dataset. Second, it will start to add new itemset select from length-1 itemset into original itemset to see if new itemset also satisfy the constrain or not. Here we generate length-2 frequent itemset. And we keep following the same mechanism until there is not length-k frequent itemset. In order to avoid duplicated computation, we set up a precondition which only the frequent itemset can join frequent itemset to form a length-n+1 itemset. With all the technique above, we can conclude our algorithm completed. Lastly we will show our test result in the following section.

1.2 Rule generation

Rules are generated using each frequent item set which has been obtained from first step. The basic idea is to enumerate all non-empty subsets of the frequent set and generate rules.

On step one, we iterate each element in the frequent item set and use it as the right part of a rule, use its complement set as left part of the rule. This gives a base set of rules. Prune criteria is applied to eliminate the low confident rules.

On step two, two for-loops are used for enumerating the combination of two rules in the set of last level(base set). For each combination, a new rule is generated by taking intersection of two left parts as new left part and union of two right parts as new right part. This operation can reduce one item in left part and add one item to right part. Also, prune criteria should be applied. This procedure generates next level of rule set. Step two is repeated until left part has all length one set.

Note that if the frequent item set has only one item, no rule can be obtained so directly return an empty rule set.

2 Test Result

2.1 frequent itemset result with different support threshold

Support is set to be: 30.0%

```
number of length-1 lengths frequent itemsets: 196
number of length-2 lengths frequent itemsets: 5340
number of length-3 lengths frequent itemsets: 5287
number of length-4 lengths frequent itemsets: 1518
number of length-5 lengths frequent itemsets: 438
number of length-6 lengths frequent itemsets: 88
number of length-7 lengths frequent itemsets: 11
number of length-8 lengths frequent itemsets: 1
number of all lengths frequent itemsets: 12879
```

Support is set to be: 40.0%

```
number of length-1 lengths frequent itemsets: 167
number of length-2 lengths frequent itemsets: 753
number of length-3 lengths frequent itemsets: 149
number of length-4 lengths frequent itemsets: 7
number of length-5 lengths frequent itemsets: 1
number of all lengths frequent itemsets: 1077
```

Support is set to be: 50.0%

```
number of length-1 lengths frequent itemsets: 109
number of length-2 lengths frequent itemsets: 63
number of length-3 lengths frequent itemsets: 2
number of all lengths frequent itemsets: 174
```

Support is set to be: 60.0%

```
number of length-1 lengths frequent itemsets: 34
number of length-2 lengths frequent itemsets: 2
number of all lengths frequent itemsets: 36
```

Support is set to be: 70.0%

```
number of length-1 lengths frequent itemsets: 7
number of all lengths frequent itemsets: 7
```

2.2 Rule Template test result

result11

26

```
{G10_Down}->{G59_Up}
{G13_Down}->{G59_Up}
{G1_Up}->{G59_Up}
```

```

{G28_Down}->{G59_Up}
{G32_Down}->{G59_Up}
{G38_Down}->{G59_Up}
{G59_Up,G72_Up}->{G82_Down}
{G59_Up,G72_Up}->{G96_Down}
{G59_Up,G82_Down}->{G72_Up}
{G59_Up,G96_Down}->{G72_Up}
{G59_Up}->{G13_Down}
{G59_Up}->{G72_Up}
{G59_Up}->{G82_Down}
{G59_Up}->{G88_Down}
{G59_Up}->{G96_Down}
{G6_Up}->{G59_Up}
{G72_Up,G82_Down}->{G59_Up}
{G72_Up,G96_Down}->{G59_Up}
{G72_Up}->{G59_Up,G82_Down}
{G72_Up}->{G59_Up}
{G82_Down}->{G59_Up,G72_Up}
{G82_Down}->{G59_Up}
{G87_Up}->{G59_Up}
{G88_Down}->{G59_Up}
{G96_Down}->{G59_Up,G72_Up}
{G96_Down}->{G59_Up}

```

result12

91

```

{G10_Down}->{G1_Up}
{G10_Down}->{G28_Down}
{G10_Down}->{G38_Down}
{G10_Down}->{G47_Up}
{G10_Down}->{G70_Down}
{G10_Down}->{G88_Down}
{G10_Down}->{G94_Up}
{G13_Down}->{G28_Down}
{G13_Down}->{G6_Up}
{G13_Down}->{G72_Up}
{G13_Down}->{G82_Down}
{G1_Up}->{G10_Down}
{G1_Up}->{G38_Down}
{G1_Up}->{G54_Up}
{G1_Up}->{G67_Up}
{G1_Up}->{G70_Down}
{G1_Up}->{G72_Up}
{G24_Down}->{G54_Up}
{G24_Down}->{G88_Down}
{G28_Down}->{G10_Down}
{G28_Down}->{G13_Down}
{G28_Down}->{G2_Down}

```

```

{G28_Down}->{G32_Down}
{G28_Down}->{G38_Down}
{G28_Down}->{G41_Down}
{G28_Down}->{G47_Up}
{G28_Down}->{G52_Down}
{G28_Down}->{G6_Up}
{G28_Down}->{G87_Up}
{G28_Down}->{G88_Down}
{G2_Down}->{G28_Down}
{G2_Down}->{G38_Down}
{G32_Down}->{G28_Down}
{G32_Down}->{G38_Down}
{G32_Down}->{G6_Up}
{G32_Down}->{G72_Up}
{G38_Down}->{G10_Down}
{G38_Down}->{G1_Up}
{G38_Down}->{G28_Down}
{G38_Down}->{G32_Down}
{G38_Down}->{G47_Up}
{G38_Down}->{G52_Down}
{G38_Down}->{G70_Down}
{G38_Down}->{G91_Up}
{G41_Down}->{G28_Down}
{G41_Down}->{G38_Down}
{G41_Down}->{G88_Down}
{G47_Up}->{G10_Down}
{G47_Up}->{G28_Down}
{G47_Up}->{G38_Down}
{G52_Down}->{G28_Down}
{G52_Down}->{G38_Down}
{G54_Up}->{G1_Up}
{G54_Up}->{G24_Down}
{G54_Up}->{G88_Down}
{G65_Down}->{G38_Down}
{G67_Up}->{G1_Up}
{G67_Up}->{G38_Down}
{G6_Up}->{G13_Down}
{G6_Up}->{G28_Down}
{G6_Up}->{G32_Down}
{G6_Up}->{G38_Down}
{G70_Down}->{G10_Down}
{G70_Down}->{G1_Up}
{G70_Down}->{G38_Down}
{G72_Up}->{G13_Down}
{G72_Up}->{G1_Up}
{G72_Up}->{G82_Down}
{G72_Up}->{G96_Down}
{G82_Down}->{G13_Down}

```

```

{G82_Down}->{G72_Up}
{G82_Down}->{G96_Down}
{G82_Down}->{G97_Down}
{G87_Up}->{G28_Down}
{G87_Up}->{G88_Down}
{G88_Down}->{G10_Down}
{G88_Down}->{G24_Down}
{G88_Down}->{G28_Down}
{G88_Down}->{G38_Down}
{G88_Down}->{G41_Down}
{G88_Down}->{G54_Up}
{G88_Down}->{G87_Up}
{G88_Down}->{G8_Up}
{G8_Up}->{G88_Down}
{G91_Up}->{G38_Down}
{G94_Up}->{G10_Down}
{G94_Up}->{G38_Down}
{G96_Down}->{G72_Up}
{G96_Down}->{G82_Down}
{G97_Down}->{G72_Up}
{G97_Down}->{G82_Down}

```

result13

39

```

{G10_Down}->{G1_Up}
{G10_Down}->{G28_Down}
{G10_Down}->{G38_Down}
{G10_Down}->{G47_Up}
{G10_Down}->{G70_Down}
{G10_Down}->{G88_Down}
{G10_Down}->{G94_Up}
{G13_Down}->{G59_Up}
{G1_Up}->{G10_Down}
{G1_Up}->{G59_Up}
{G28_Down}->{G10_Down}
{G28_Down}->{G59_Up}
{G32_Down}->{G59_Up}
{G38_Down}->{G10_Down}
{G38_Down}->{G59_Up}
{G47_Up}->{G10_Down}
{G59_Up,G72_Up}->{G82_Down}
{G59_Up,G72_Up}->{G96_Down}
{G59_Up,G82_Down}->{G72_Up}
{G59_Up,G96_Down}->{G72_Up}
{G59_Up}->{G13_Down}
{G59_Up}->{G72_Up}
{G59_Up}->{G82_Down}
{G59_Up}->{G88_Down}

```

```

{G59_Up}->{G96_Down}
{G6_Up}->{G59_Up}
{G70_Down}->{G10_Down}
{G72_Up,G82_Down}->{G59_Up}
{G72_Up,G96_Down}->{G59_Up}
{G72_Up}->{G59_Up,G82_Down}
{G72_Up}->{G59_Up}
{G82_Down}->{G59_Up,G72_Up}
{G82_Down}->{G59_Up}
{G87_Up}->{G59_Up}
{G88_Down}->{G10_Down}
{G88_Down}->{G59_Up}
{G94_Up}->{G10_Down}
{G96_Down}->{G59_Up,G72_Up}
{G96_Down}->{G59_Up}

```

result14

```

9
{G59_Up,G72_Up}->{G82_Down}
{G59_Up,G72_Up}->{G96_Down}
{G59_Up,G82_Down}->{G72_Up}
{G59_Up,G96_Down}->{G72_Up}
{G59_Up}->{G13_Down}
{G59_Up}->{G72_Up}
{G59_Up}->{G82_Down}
{G59_Up}->{G88_Down}
{G59_Up}->{G96_Down}

```

result15

```

108
{G10_Down}->{G1_Up}
{G10_Down}->{G28_Down}
{G10_Down}->{G38_Down}
{G10_Down}->{G47_Up}
{G10_Down}->{G59_Up}
{G10_Down}->{G70_Down}
{G10_Down}->{G88_Down}
{G10_Down}->{G94_Up}
{G13_Down}->{G28_Down}
{G13_Down}->{G59_Up}
{G13_Down}->{G6_Up}
{G13_Down}->{G72_Up}
{G13_Down}->{G82_Down}
{G1_Up}->{G10_Down}
{G1_Up}->{G38_Down}
{G1_Up}->{G54_Up}
{G1_Up}->{G59_Up}
{G1_Up}->{G67_Up}

```

```

{G1_Up}->{G70_Down}
{G1_Up}->{G72_Up}
{G24_Down}->{G54_Up}
{G24_Down}->{G88_Down}
{G28_Down}->{G10_Down}
{G28_Down}->{G13_Down}
{G28_Down}->{G2_Down}
{G28_Down}->{G32_Down}
{G28_Down}->{G38_Down}
{G28_Down}->{G41_Down}
{G28_Down}->{G47_Up}
{G28_Down}->{G52_Down}
{G28_Down}->{G59_Up}
{G28_Down}->{G6_Up}
{G28_Down}->{G87_Up}
{G28_Down}->{G88_Down}
{G2_Down}->{G28_Down}
{G2_Down}->{G38_Down}
{G32_Down}->{G28_Down}
{G32_Down}->{G38_Down}
{G32_Down}->{G59_Up}
{G32_Down}->{G6_Up}
{G32_Down}->{G72_Up}
{G38_Down}->{G10_Down}
{G38_Down}->{G1_Up}
{G38_Down}->{G28_Down}
{G38_Down}->{G32_Down}
{G38_Down}->{G47_Up}
{G38_Down}->{G52_Down}
{G38_Down}->{G59_Up}
{G38_Down}->{G70_Down}
{G38_Down}->{G91_Up}
{G41_Down}->{G28_Down}
{G41_Down}->{G38_Down}
{G41_Down}->{G88_Down}
{G47_Up}->{G10_Down}
{G47_Up}->{G28_Down}
{G47_Up}->{G38_Down}
{G52_Down}->{G28_Down}
{G52_Down}->{G38_Down}
{G54_Up}->{G1_Up}
{G54_Up}->{G24_Down}
{G54_Up}->{G88_Down}
{G65_Down}->{G38_Down}
{G67_Up}->{G1_Up}
{G67_Up}->{G38_Down}
{G6_Up}->{G13_Down}
{G6_Up}->{G28_Down}

```

```

{G6_Up}->{G32_Down}
{G6_Up}->{G38_Down}
{G6_Up}->{G59_Up}
{G70_Down}->{G10_Down}
{G70_Down}->{G1_Up}
{G70_Down}->{G38_Down}
{G72_Up,G82_Down}->{G59_Up}
{G72_Up,G96_Down}->{G59_Up}
{G72_Up}->{G13_Down}
{G72_Up}->{G1_Up}
{G72_Up}->{G59_Up,G82_Down}
{G72_Up}->{G59_Up}
{G72_Up}->{G82_Down}
{G72_Up}->{G96_Down}
{G82_Down}->{G13_Down}
{G82_Down}->{G59_Up,G72_Up}
{G82_Down}->{G59_Up}
{G82_Down}->{G72_Up}
{G82_Down}->{G96_Down}
{G82_Down}->{G97_Down}
{G87_Up}->{G28_Down}
{G87_Up}->{G59_Up}
{G87_Up}->{G88_Down}
{G88_Down}->{G10_Down}
{G88_Down}->{G24_Down}
{G88_Down}->{G28_Down}
{G88_Down}->{G38_Down}
{G88_Down}->{G41_Down}
{G88_Down}->{G54_Up}
{G88_Down}->{G59_Up}
{G88_Down}->{G87_Up}
{G88_Down}->{G8_Up}
{G8_Up}->{G88_Down}
{G91_Up}->{G38_Down}
{G94_Up}->{G10_Down}
{G94_Up}->{G38_Down}
{G96_Down}->{G59_Up,G72_Up}
{G96_Down}->{G59_Up}
{G96_Down}->{G72_Up}
{G96_Down}->{G82_Down}
{G97_Down}->{G72_Up}
{G97_Down}->{G82_Down}

```

result16

17

```

{G10_Down}->{G1_Up}
{G10_Down}->{G28_Down}
{G10_Down}->{G38_Down}

```



```

{G10_Down}->{G47_Up}
{G10_Down}->{G59_Up}
{G10_Down}->{G70_Down}
{G10_Down}->{G88_Down}
{G10_Down}->{G94_Up}
{G59_Up,G72_Up}->{G82_Down}
{G59_Up,G72_Up}->{G96_Down}
{G59_Up,G82_Down}->{G72_Up}
{G59_Up,G96_Down}->{G72_Up}
{G59_Up}->{G13_Down}
{G59_Up}->{G72_Up}
{G59_Up}->{G82_Down}
{G59_Up}->{G88_Down}
{G59_Up}->{G96_Down}

```

result17

17

```

{G10_Down}->{G59_Up}
{G13_Down}->{G59_Up}
{G1_Up}->{G59_Up}
{G28_Down}->{G59_Up}
{G32_Down}->{G59_Up}
{G38_Down}->{G59_Up}
{G6_Up}->{G59_Up}
{G72_Up,G82_Down}->{G59_Up}
{G72_Up,G96_Down}->{G59_Up}
{G72_Up}->{G59_Up,G82_Down}
{G72_Up}->{G59_Up}
{G82_Down}->{G59_Up,G72_Up}
{G82_Down}->{G59_Up}
{G87_Up}->{G59_Up}
{G88_Down}->{G59_Up}
{G96_Down}->{G59_Up,G72_Up}
{G96_Down}->{G59_Up}

```

result18

100

```

{G10_Down}->{G1_Up}
{G10_Down}->{G28_Down}
{G10_Down}->{G38_Down}
{G10_Down}->{G47_Up}
{G10_Down}->{G70_Down}
{G10_Down}->{G88_Down}
{G10_Down}->{G94_Up}
{G13_Down}->{G28_Down}
{G13_Down}->{G6_Up}
{G13_Down}->{G72_Up}
{G13_Down}->{G82_Down}

```

```

{G1_Up}->{G10_Down}
{G1_Up}->{G38_Down}
{G1_Up}->{G54_Up}
{G1_Up}->{G67_Up}
{G1_Up}->{G70_Down}
{G1_Up}->{G72_Up}
{G24_Down}->{G54_Up}
{G24_Down}->{G88_Down}
{G28_Down}->{G10_Down}
{G28_Down}->{G13_Down}
{G28_Down}->{G2_Down}
{G28_Down}->{G32_Down}
{G28_Down}->{G38_Down}
{G28_Down}->{G41_Down}
{G28_Down}->{G47_Up}
{G28_Down}->{G52_Down}
{G28_Down}->{G6_Up}
{G28_Down}->{G87_Up}
{G28_Down}->{G88_Down}
{G2_Down}->{G28_Down}
{G2_Down}->{G38_Down}
{G32_Down}->{G28_Down}
{G32_Down}->{G38_Down}
{G32_Down}->{G6_Up}
{G32_Down}->{G72_Up}
{G38_Down}->{G10_Down}
{G38_Down}->{G1_Up}
{G38_Down}->{G28_Down}
{G38_Down}->{G32_Down}
{G38_Down}->{G47_Up}
{G38_Down}->{G52_Down}
{G38_Down}->{G70_Down}
{G38_Down}->{G91_Up}
{G41_Down}->{G28_Down}
{G41_Down}->{G38_Down}
{G41_Down}->{G88_Down}
{G47_Up}->{G10_Down}
{G47_Up}->{G28_Down}
{G47_Up}->{G38_Down}
{G52_Down}->{G28_Down}
{G52_Down}->{G38_Down}
{G54_Up}->{G1_Up}
{G54_Up}->{G24_Down}
{G54_Up}->{G88_Down}
{G59_Up, G72_Up}->{G82_Down}
{G59_Up, G72_Up}->{G96_Down}
{G59_Up, G82_Down}->{G72_Up}
{G59_Up, G96_Down}->{G72_Up}

```

```

{G59_Up}->{G13_Down}
{G59_Up}->{G72_Up}
{G59_Up}->{G82_Down}
{G59_Up}->{G88_Down}
{G59_Up}->{G96_Down}
{G65_Down}->{G38_Down}
{G67_Up}->{G1_Up}
{G67_Up}->{G38_Down}
{G6_Up}->{G13_Down}
{G6_Up}->{G28_Down}
{G6_Up}->{G32_Down}
{G6_Up}->{G38_Down}
{G70_Down}->{G10_Down}
{G70_Down}->{G1_Up}
{G70_Down}->{G38_Down}
{G72_Up}->{G13_Down}
{G72_Up}->{G1_Up}
{G72_Up}->{G82_Down}
{G72_Up}->{G96_Down}
{G82_Down}->{G13_Down}
{G82_Down}->{G72_Up}
{G82_Down}->{G96_Down}
{G82_Down}->{G97_Down}
{G87_Up}->{G28_Down}
{G87_Up}->{G88_Down}
{G88_Down}->{G10_Down}
{G88_Down}->{G24_Down}
{G88_Down}->{G28_Down}
{G88_Down}->{G38_Down}
{G88_Down}->{G41_Down}
{G88_Down}->{G54_Up}
{G88_Down}->{G87_Up}
{G88_Down}->{G8_Up}
{G8_Up}->{G88_Down}
{G91_Up}->{G38_Down}
{G94_Up}->{G10_Down}
{G94_Up}->{G38_Down}
{G96_Down}->{G72_Up}
{G96_Down}->{G82_Down}
{G97_Down}->{G72_Up}
{G97_Down}->{G82_Down}

```

result19

24

```

{G10_Down}->{G59_Up}
{G13_Down}->{G59_Up}
{G1_Up}->{G10_Down}
{G1_Up}->{G59_Up}

```

```

{G28_Down}->{G10_Down}
{G28_Down}->{G59_Up}
{G32_Down}->{G59_Up}
{G38_Down}->{G10_Down}
{G38_Down}->{G59_Up}
{G47_Up}->{G10_Down}
{G6_Up}->{G59_Up}
{G70_Down}->{G10_Down}
{G72_Up, G82_Down}->{G59_Up}
{G72_Up, G96_Down}->{G59_Up}
{G72_Up}->{G59_Up, G82_Down}
{G72_Up}->{G59_Up}
{G82_Down}->{G59_Up, G72_Up}
{G82_Down}->{G59_Up}
{G87_Up}->{G59_Up}
{G88_Down}->{G10_Down}
{G88_Down}->{G59_Up}
{G94_Up}->{G10_Down}
{G96_Down}->{G59_Up, G72_Up}
{G96_Down}->{G59_Up}

```

result21

9

```

{G59_Up, G72_Up}->{G82_Down}
{G59_Up, G72_Up}->{G96_Down}
{G59_Up, G82_Down}->{G72_Up}
{G59_Up, G96_Down}->{G72_Up}
{G72_Up, G82_Down}->{G59_Up}
{G72_Up, G96_Down}->{G59_Up}
{G72_Up}->{G59_Up, G82_Down}
{G82_Down}->{G59_Up, G72_Up}
{G96_Down}->{G59_Up, G72_Up}

```

result22

6

```

{G59_Up, G72_Up}->{G82_Down}
{G59_Up, G72_Up}->{G96_Down}
{G59_Up, G82_Down}->{G72_Up}
{G59_Up, G96_Down}->{G72_Up}
{G72_Up, G82_Down}->{G59_Up}
{G72_Up, G96_Down}->{G59_Up}

```

result23

117

```

{G10_Down}->{G1_Up}
{G10_Down}->{G28_Down}
{G10_Down}->{G38_Down}
{G10_Down}->{G47_Up}

```

```

{G10_Down}->{G59_Up}
{G10_Down}->{G70_Down}
{G10_Down}->{G88_Down}
{G10_Down}->{G94_Up}
{G13_Down}->{G28_Down}
{G13_Down}->{G59_Up}
{G13_Down}->{G6_Up}
{G13_Down}->{G72_Up}
{G13_Down}->{G82_Down}
{G1_Up}->{G10_Down}
{G1_Up}->{G38_Down}
{G1_Up}->{G54_Up}
{G1_Up}->{G59_Up}
{G1_Up}->{G67_Up}
{G1_Up}->{G70_Down}
{G1_Up}->{G72_Up}
{G24_Down}->{G54_Up}
{G24_Down}->{G88_Down}
{G28_Down}->{G10_Down}
{G28_Down}->{G13_Down}
{G28_Down}->{G2_Down}
{G28_Down}->{G32_Down}
{G28_Down}->{G38_Down}
{G28_Down}->{G41_Down}
{G28_Down}->{G47_Up}
{G28_Down}->{G52_Down}
{G28_Down}->{G59_Up}
{G28_Down}->{G6_Up}
{G28_Down}->{G87_Up}
{G28_Down}->{G88_Down}
{G2_Down}->{G28_Down}
{G2_Down}->{G38_Down}
{G32_Down}->{G28_Down}
{G32_Down}->{G38_Down}
{G32_Down}->{G59_Up}
{G32_Down}->{G6_Up}
{G32_Down}->{G72_Up}
{G38_Down}->{G10_Down}
{G38_Down}->{G1_Up}
{G38_Down}->{G28_Down}
{G38_Down}->{G32_Down}
{G38_Down}->{G47_Up}
{G38_Down}->{G52_Down}
{G38_Down}->{G59_Up}
{G38_Down}->{G70_Down}
{G38_Down}->{G91_Up}
{G41_Down}->{G28_Down}
{G41_Down}->{G38_Down}

```

```

{G41_Down}->{G88_Down}
{G47_Up}->{G10_Down}
{G47_Up}->{G28_Down}
{G47_Up}->{G38_Down}
{G52_Down}->{G28_Down}
{G52_Down}->{G38_Down}
{G54_Up}->{G1_Up}
{G54_Up}->{G24_Down}
{G54_Up}->{G88_Down}
{G59_Up,G72_Up}->{G82_Down}
{G59_Up,G72_Up}->{G96_Down}
{G59_Up,G82_Down}->{G72_Up}
{G59_Up,G96_Down}->{G72_Up}
{G59_Up}->{G13_Down}
{G59_Up}->{G72_Up}
{G59_Up}->{G82_Down}
{G59_Up}->{G88_Down}
{G59_Up}->{G96_Down}
{G65_Down}->{G38_Down}
{G67_Up}->{G1_Up}
{G67_Up}->{G38_Down}
{G6_Up}->{G13_Down}
{G6_Up}->{G28_Down}
{G6_Up}->{G32_Down}
{G6_Up}->{G38_Down}
{G6_Up}->{G59_Up}
{G70_Down}->{G10_Down}
{G70_Down}->{G1_Up}
{G70_Down}->{G38_Down}
{G72_Up,G82_Down}->{G59_Up}
{G72_Up,G96_Down}->{G59_Up}
{G72_Up}->{G13_Down}
{G72_Up}->{G1_Up}
{G72_Up}->{G59_Up,G82_Down}
{G72_Up}->{G59_Up}
{G72_Up}->{G82_Down}
{G72_Up}->{G96_Down}
{G82_Down}->{G13_Down}
{G82_Down}->{G59_Up,G72_Up}
{G82_Down}->{G59_Up}
{G82_Down}->{G72_Up}
{G82_Down}->{G96_Down}
{G82_Down}->{G97_Down}
{G87_Up}->{G28_Down}
{G87_Up}->{G59_Up}
{G87_Up}->{G88_Down}
{G88_Down}->{G10_Down}
{G88_Down}->{G24_Down}

```

```

{G88_Down}->{G28_Down}
{G88_Down}->{G38_Down}
{G88_Down}->{G41_Down}
{G88_Down}->{G54_Up}
{G88_Down}->{G59_Up}
{G88_Down}->{G87_Up}
{G88_Down}->{G8_Up}
{G8_Up}->{G88_Down}
{G91_Up}->{G38_Down}
{G94_Up}->{G10_Down}
{G94_Up}->{G38_Down}
{G96_Down}->{G59_Up,G72_Up}
{G96_Down}->{G59_Up}
{G96_Down}->{G72_Up}
{G96_Down}->{G82_Down}
{G97_Down}->{G72_Up}
{G97_Down}->{G82_Down}

```

result31

8

```

{G10_Down}->{G1_Up}
{G10_Down}->{G28_Down}
{G10_Down}->{G38_Down}
{G10_Down}->{G47_Up}
{G10_Down}->{G59_Up}
{G10_Down}->{G70_Down}
{G10_Down}->{G88_Down}
{G10_Down}->{G94_Up}

```

result32

0

result33

11

```

{G10_Down}->{G1_Up}
{G10_Down}->{G28_Down}
{G10_Down}->{G38_Down}
{G10_Down}->{G47_Up}
{G10_Down}->{G59_Up}
{G10_Down}->{G70_Down}
{G10_Down}->{G88_Down}
{G10_Down}->{G94_Up}
{G72_Up}->{G59_Up,G82_Down}
{G82_Down}->{G59_Up,G72_Up}
{G96_Down}->{G59_Up,G72_Up}

```

result34

0

117

```

{G10_Down}->{G1_Up}
{G10_Down}->{G28_Down}
{G10_Down}->{G38_Down}
{G10_Down}->{G47_Up}
{G10_Down}->{G59_Up}
{G10_Down}->{G70_Down}
{G10_Down}->{G88_Down}
{G10_Down}->{G94_Up}
{G13_Down}->{G28_Down}
{G13_Down}->{G59_Up}
{G13_Down}->{G6_Up}
{G13_Down}->{G72_Up}
{G13_Down}->{G82_Down}
{G1_Up}->{G10_Down}
{G1_Up}->{G38_Down}
{G1_Up}->{G54_Up}
{G1_Up}->{G59_Up}
{G1_Up}->{G67_Up}
{G1_Up}->{G70_Down}
{G1_Up}->{G72_Up}
{G24_Down}->{G54_Up}
{G24_Down}->{G88_Down}
{G28_Down}->{G10_Down}
{G28_Down}->{G13_Down}
{G28_Down}->{G2_Down}
{G28_Down}->{G32_Down}
{G28_Down}->{G38_Down}
{G28_Down}->{G41_Down}
{G28_Down}->{G47_Up}
{G28_Down}->{G52_Down}
{G28_Down}->{G59_Up}
{G28_Down}->{G6_Up}
{G28_Down}->{G87_Up}
{G28_Down}->{G88_Down}
{G2_Down}->{G28_Down}
{G2_Down}->{G38_Down}
{G32_Down}->{G28_Down}
{G32_Down}->{G38_Down}
{G32_Down}->{G59_Up}
{G32_Down}->{G6_Up}
{G32_Down}->{G72_Up}
{G38_Down}->{G10_Down}
{G38_Down}->{G1_Up}
{G38_Down}->{G28_Down}
{G38_Down}->{G32_Down}
{G38_Down}->{G47_Up}

```



```

{G38_Down}->{G52_Down}
{G38_Down}->{G59_Up}
{G38_Down}->{G70_Down}
{G38_Down}->{G91_Up}
{G41_Down}->{G28_Down}
{G41_Down}->{G38_Down}
{G41_Down}->{G88_Down}
{G47_Up}->{G10_Down}
{G47_Up}->{G28_Down}
{G47_Up}->{G38_Down}
{G52_Down}->{G28_Down}
{G52_Down}->{G38_Down}
{G54_Up}->{G1_Up}
{G54_Up}->{G24_Down}
{G54_Up}->{G88_Down}
{G59_Up,G72_Up}->{G82_Down}
{G59_Up,G72_Up}->{G96_Down}
{G59_Up,G82_Down}->{G72_Up}
{G59_Up,G96_Down}->{G72_Up}
{G59_Up}->{G13_Down}
{G59_Up}->{G72_Up}
{G59_Up}->{G82_Down}
{G59_Up}->{G88_Down}
{G59_Up}->{G96_Down}
{G65_Down}->{G38_Down}
{G67_Up}->{G1_Up}
{G67_Up}->{G38_Down}
{G6_Up}->{G13_Down}
{G6_Up}->{G28_Down}
{G6_Up}->{G32_Down}
{G6_Up}->{G38_Down}
{G6_Up}->{G59_Up}
{G70_Down}->{G10_Down}
{G70_Down}->{G1_Up}
{G70_Down}->{G38_Down}
{G72_Up,G82_Down}->{G59_Up}
{G72_Up,G96_Down}->{G59_Up}
{G72_Up}->{G13_Down}
{G72_Up}->{G1_Up}
{G72_Up}->{G59_Up,G82_Down}
{G72_Up}->{G59_Up}
{G72_Up}->{G82_Down}
{G72_Up}->{G96_Down}
{G82_Down}->{G13_Down}
{G82_Down}->{G59_Up,G72_Up}
{G82_Down}->{G59_Up}
{G82_Down}->{G72_Up}
{G82_Down}->{G96_Down}

```

```

{G82_Down}->{G97_Down}
{G87_Up}->{G28_Down}
{G87_Up}->{G59_Up}
{G87_Up}->{G88_Down}
{G88_Down}->{G10_Down}
{G88_Down}->{G24_Down}
{G88_Down}->{G28_Down}
{G88_Down}->{G38_Down}
{G88_Down}->{G41_Down}
{G88_Down}->{G54_Up}
{G88_Down}->{G59_Up}
{G88_Down}->{G87_Up}
{G88_Down}->{G8_Up}
{G8_Up}->{G88_Down}
{G91_Up}->{G38_Down}
{G94_Up}->{G10_Down}
{G94_Up}->{G38_Down}
{G96_Down}->{G59_Up, G72_Up}
{G96_Down}->{G59_Up}
{G96_Down}->{G72_Up}
{G96_Down}->{G82_Down}
{G97_Down}->{G72_Up}
{G97_Down}->{G82_Down}

```

result36

3

```

{G72_Up}->{G59_Up, G82_Down}
{G82_Down}->{G59_Up, G72_Up}
{G96_Down}->{G59_Up, G72_Up}

```