

The test cases in this document are separated according to the dataset on which the RICO algorithm is run. The two primary datasets in this document will be referred to by the dataset names described below:

- Small Test Dataset (table3_10_fg.arff)
- Large Test Dataset (wilkinsonMatrix.arff)

Additional testing was performed on some datasets that are provided as samples with Weka; however, the above datasets are sufficient to demonstrate all our test cases.

(NOTE: Different versions of Ruby will result in different orderings for the generated, and subsequently pruned, rules.)

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Using RICO

The command 'rico' is how our implementation of RICO is used. It may be run without any arguments, in which case it will prompt for an ARFF file and all options. It also supports command line options, and will prompt for unspecified options it requires.

The options are as follows:

- `--help, -h` : print a summary of command options
- `-d, --decision [attr_name, attr_name, ...]` : Specify names of decision attributes
- `-c, --covering [attr_name, attr_name, ...]` : Specify names of attributes to use in coverings
- `-a, --max-attrs x` : Maximum number of attributes to have in a covering
- `-r, --min-rule-coverage x` : Minimum coverage a rule must have to be reported
- `-p, --prune` : Prune unnecessary conditions from generated rules

RICO has been tested on Ruby 1.8 and 2.0. It requires rubygem to be installed, and will automatically install any gems it requires that are not already present.

Small Test Dataset – Test Case #1

- Single decision attribute
- No limit on attributes considered for coverings
- No minimum instance coverage for reported rules
- Redundant rules not pruned

Attributes to partition on: ["a", "b", "c", "d", "g"]

Decision attributes: ["f"]

Value: [0.0] Occurrences: 2

Value: [1.0] Occurrences: 2

Value: [2.0] Occurrences: 2

Value: [3.0] Occurrences: 2

Coverings:

["a", "b"]

[[[0.0, "L", 0.0], 2], [[0.0, "R", 1.0], 2], [[1.0, "R", 2.0], 2], [[2.0, "S", 3.0], 2]]

["a", "c"]

[[[0.0, 0.0, 0.0], 2], [[0.0, 1.0, 1.0], 2], [[1.0, 0.0, 2.0], 2], [[2.0, 2.0, 3.0], 2]]

["b", "c"]

[[["L", 0.0, 0.0], 2], [{"R", 1.0, 1.0], 2], [{"R", 0.0, 2.0], 2], [{"S", 2.0, 3.0], 2]]

["b", "g"]

[[["L", "L", 0.0], 2], [{"R", "L", 1.0], 2], [{"R", "H", 2.0], 2], [{"S", "H", 3.0], 2]]

["c", "g"]

[[[0.0, "L", 0.0], 2], [[1.0, "L", 1.0], 2], [[0.0, "H", 2.0], 2], [[2.0, "H", 3.0], 2]]

It is fairly easy to verify that the results produced from this particular option set is correct, however, the rules produced from the coverings are obviously unpruned. The next test case, in contrast, shows the results of the same option set with pruning enabled.

Small Test Dataset – Test Case #2

- Single decision attribute
- No limit on attributes considered for coverings
- No minimum instance coverage for reported rules
- Redundant rules pruned

Attributes to partition on: ["a", "b", "c", "d", "g"]

Decision attributes: ["f"]

Value: [0.0] Occurrences: 2

Value: [1.0] Occurrences: 2

Value: [2.0] Occurrences: 2

Value: [3.0] Occurrences: 2

Coverings:

["a", "b"]

[[["_", "L", 0.0], 2], [[0.0, "R", 1.0], 2], [[1.0, "_", 2.0], 2], [[2.0, "_", 3.0], 2]]

["a", "c"]

[[[0.0, 0.0, 0.0], 2], [["_", 1.0, 1.0], 2], [[1.0, "_", 2.0], 2], [[2.0, "_", 3.0], 2]]

["b", "c"]

[[["L", "_", 0.0], 2], [["_", 1.0, 1.0], 2], [["R", 0.0, 2.0], 2], [["S", "_", 3.0], 2]]

["b", "g"]

[[["L", "_", 0.0], 2], [["R", "L", 1.0], 2], [["R", "H", 2.0], 2], [["S", "_", 3.0], 2]]

["c", "g"]

[[[0.0, "L", 0.0], 2], [[1.0, "_", 1.0], 2], [[0.0, "H", 2.0], 2], [[2.0, "_", 3.0], 2]]

While this dataset is not large enough that pruning will cause rules to be combined, it does correctly eliminate redundant conditions from the set of antecedents.

Small Test Dataset – Test Case #3

- Multiple decision attributes
- No limit on attributes considered for coverings
- No minimum instance coverage for reported rules
- Redundant rules not pruned

Attributes to partition on: ["a", "b", "c", "d"]

Decision attributes: ["f"]

Value: [0.0] Occurrences: 2

Value: [1.0] Occurrences: 2

Value: [2.0] Occurrences: 2

Value: [3.0] Occurrences: 2

Decision attributes: ["g"]

Value: ["L"] Occurrences: 4

Value: ["H"] Occurrences: 4

Decision attributes: ["f", "g"]

Value: [0.0, "L"] Occurrences: 2

Value: [1.0, "L"] Occurrences: 2

Value: [2.0, "H"] Occurrences: 2

Value: [3.0, "H"] Occurrences: 2

Coverings:

["a", "b"]

[[[0.0, "L", 0.0, "L"], 2], [[0.0, "R", 1.0, "L"], 2], [[1.0, "R", 2.0, "H"], 2], [[2.0, "S", 3.0, "H"], 2]]

["a", "c"]

[[[0.0, 0.0, 0.0, "L"], 2], [[0.0, 1.0, 1.0, "L"], 2], [[1.0, 0.0, 2.0, "H"], 2], [[2.0, 2.0, 3.0, "H"], 2]]

["b", "c"]

[[["L", 0.0, 0.0, "L"], 2], [{"R", 1.0, 1.0, "L"], 2], [{"R", 0.0, 2.0, "H"], 2], [{"S", 2.0, 3.0, "H"], 2]]

The results for the test case involving multiple decision attributes are nearly identical to the results for the test case involving a single decision attribute, except now the amount of resulting coverings is reduced due to the smaller set of attributes to be considered for coverings.

Small Test Dataset – Test Case #4

- Multiple decision attributes
- No limit on attributes considered for coverings
- No minimum instance coverage for reported rules
- Redundant rules pruned

Attributes to partition on: ["a", "b", "c", "d"]

Decision attributes: ["f"]

Value: [0.0] Occurrences: 2

Value: [1.0] Occurrences: 2

Value: [2.0] Occurrences: 2

Value: [3.0] Occurrences: 2

Decision attributes: ["g"]

Value: ["L"] Occurrences: 4

Value: ["H"] Occurrences: 4

Decision attributes: ["f", "g"]

Value: [0.0, "L"] Occurrences: 2

Value: [1.0, "L"] Occurrences: 2

Value: [2.0, "H"] Occurrences: 2

Value: [3.0, "H"] Occurrences: 2

Coverings:

["a", "b"]

[[["_", "L", 0.0, "L"], 2], [[0.0, "R", 1.0, "L"], 2], [[1.0, "_", 2.0, "H"], 2], [[2.0, "_", 3.0, "H"], 2]]

["a", "c"]

[[[0.0, 0.0, 0.0, "L"], 2], [["_", 1.0, 1.0, "L"], 2], [[1.0, "_", 2.0, "H"], 2], [[2.0, "_", 3.0, "H"], 2]]

["b", "c"]

[[["L", "_", 0.0, "L"], 2], [["_", 1.0, 1.0, "L"], 2], [["R", 0.0, 2.0, "H"], 2], [["S", "_", 3.0, "H"], 2]]

The pruned/unpruned results for test cases involving multiple decision attributes also show proper pruning of conditions from the set of antecedents, in the same vein as the results from the test cases involving a single decision attribute.

Large Test Dataset – Test Case #1

- Single decision attribute
- Number of attributes considered for coverings limited to 3
- No minimum instance coverage for reported rules
- Redundant rules not pruned

Attributes to partition on: ["a0", "a1", "a2", "a3", "a4", "a5", "a6", "a7", "a8", "a9", "a10", "a11", "a12", "a13", "a14", "a15", "a16", "a17", "a18", "a19", "a20", "a21", "a22", "a23", "a24", "a25", "a26", "a27", "a28", "a29", "a30", "a31", "a32", "a33", "a34", "a35", "a36", "a37", "a38", "a39", "a40", "a41", "a42", "a43", "a44", "a45", "a46", "a47", "a48", "a49", "a50", "a51", "a52", "a53", "a54", "a55", "a56", "a57", "a58", "a59", "a60", "a61", "a62", "a63", "a64", "a65", "a66", "a67", "a68", "a69", "a70", "a72", "a73", "a74", "a75", "a76", "a77"]

Decision attributes: ["a71"]

Value: 2.0	Occurrences: 2
Value: ?	Occurrences: 5
Value: 1.0	Occurrences: 4
Value: 0.0	Occurrences: 14

Coverings:

["a0", "a2", "a69"]
[[["0.0", "?", "?", "?"], 1], [[["0.0", 1.0, "?", 0.0], 1], [[["0.0", "?", 0.0, 0.0], 1], [[["1.0", "?", 0.0, 0.0], 2], [[["1.0", 1.0, "?", "?"], 1], [[["1.0", 0.0, 1.0, 0.0], 1], [[["0.0", 0.0, 1.0, 2.0], 1], [[["0.0", 0.0, "?", "?"], 1], [[["1.0", 1.0, 1.0, 1.0], 3], [[["1.0", 1.0, 0.0, 1.0], 1], [[["?", 0.0, "?", "?"], 1], [[["?", "?", 1.0, 2.0], 1], [[["?", 0.0, 0.0, 0.0], 1], [[["?", "?", 0.0, 0.0], 3], [[["0.0", 0.0, 0.0, 0.0], 5], [[["1.0", "?", "?", "?"], 1]]

["a0", "a61", "a69"]
[[["?", 0.0, 1.0, 2.0], 1], [[["0.0", 1.0, "?", 0.0], 1], [[["1.0", "?", 0.0, 0.0], 2], [[["1.0", 1.0, "?", "?"], 2], [[["1.0", 0.0, 1.0, 1.0], 3], [[["0.0", 0.0, 1.0, 2.0], 1], [[["?", 1.0, 0.0, 0.0], 2], [[["0.0", 0.0, "?", "?"], 2], [[["1.0", 1.0, 0.0, 1.0], 1], [[["?", 0.0, 0.0, 0.0], 1], [[["1.0", 1.0, 1.0, 0.0], 1], [[["?", 0.0, 0.0, 0.0], 2], [[["0.0", 0.0, 0.0, 0.0], 4], [[["0.0", 1.0, 0.0, 0.0], 2]]

["a1", "a61", "a69"]
[[["?", 0.0, 1.0, 2.0], 1], [[["0.0", 1.0, "?", 0.0], 1], [[["1.0", "?", 0.0, 0.0], 2], [[["1.0", 1.0, "?", "?"], 2], [[["1.0", 0.0, 1.0, 1.0], 3], [[["0.0", 0.0, 1.0, 2.0], 1], [[["0.0", 1.0, 1.0, 0.0], 1], [[["?", 1.0, 0.0, 0.0], 2], [[["0.0", 0.0, "?", "?"], 3], [[["1.0", 1.0, 0.0, 1.0], 1], [[["?", 0.0, 0.0, 0.0], 2], [[["0.0", 0.0, 0.0, 0.0], 4], [[["0.0", 1.0, 0.0, 0.0], 2]]

["a1", "a69", "a72"]
[[["0.0", "?", "?", "?"], 3], [[["0.0", 1.0, "?", 2.0], 1], [[["?", 0.0, 1.0, 0.0], 1], [[["1.0", 0.0, 0.0, 1.0], 1], [[["1.0", 0.0, 1.0, 0.0], 2], [[["1.0", 1.0, 0.0, 1.0], 3], [[["?", 1.0, 0.0, 2.0], 1], [[["0.0", "?", 1.0, 0.0], 1], [[["?", 0.0, 0.0, 0.0], 3], [[["0.0", 0.0, 0.0, 0.0], 6], [[["0.0", 1.0, 0.0, 0.0], 1], [[["1.0", "?", "?", "?"], 2]]

["a2", "a5", "a69"]
[[["0.0", "?", "?", "?"], 1], [[["1.0", 1.0, "?", "?"], 1], [[["?", "?", "?", "?"], 1], [[["?", 1.0, "?", "?"], 1], [[["0.0", 0.0, 1.0, 2.0], 1], [[["?", 1.0, 0.0, 0.0], 2], [[["0.0", 1.0, 1.0, 0.0], 1], [[["0.0", 0.0, "?", "?"], 1], [[["1.0", 0.0, "?", 0.0], 1], [[["1.0", 1.0, 1.0, 1.0], 3], [[["1.0", 1.0, 0.0, 1.0], 1], [[["?", "?", 1.0, 2.0], 1], [[["?", "?", 0.0, 0.0], 4], [[["0.0", 0.0, 0.0, 0.0], 6]]

["a2", "a8", "a69"]
[[["1.0", "?", 1.0, 1.0], 1], [[["1.0", 1.0, "?", 0.0], 1], [[["1.0", 0.0, "?", "?"], 1], [[["0.0", 1.0, 1.0, 2.0], 1], [[["?", 1.0, "?", "?"], 2], [[["?", 1.0, 0.0, 0.0], 2], [[["0.0", 0.0, "?", "?"], 1], [[["0.0", 1.0, 1.0, 1.0], 2], [[["1.0", 1.0, 0.0, 1.0], 1], [[["0.0", 0.0, 1.0, 0.0], 1], [[["?", "?", 1.0, 2.0], 1], [[["?", 0.0, 0.0, 0.0], 1], [[["?", "?", 0.0, 0.0], 3], [[["0.0", 0.0, 0.0, 0.0], 6]]

["a2", "a12", "a69"]
[[["0.0", "?", 0.0, 0.0], 1], [[["1.0", "?", 1.0, 1.0], 1], [[["1.0", 1.0, "?", 0.0], 1], [[["1.0", 0.0, "?", "?"], 1], [[["?", "?", "?", "?"], 1], [[["1.0", 0.0, 0.0, 1.0], 1], [[["0.0", 0.0, 1.0, 2.0], 1], [[["?", 1.0, 0.0, 0.0], 1], [[["0.0", 0.0, "?", "?"], 2], [[["1.0", 1.0, 1.0, 1.0], 2], [[["?", "?", 1.0, 2.0], 1], [[["0.0", "?", 1.0, 0.0], 1], [[["?", "?", 0.0, 0.0], 2], [[["?", 0.0, "?", "?"], 1], [[["?", 0.0, 0.0, 0.0], 3], [[["0.0", 0.0, 0.0, 0.0], 4], [[["0.0", 1.0, 0.0, 0.0], 1]]

["a2", "a16", "a69"]
[[["0.0", "?", 0.0, 0.0], 1], [[["1.0", "?", 1.0, 1.0], 1], [[["?", "?", "?", "?"], 1], [[["1.0", 0.0, 0.0, 1.0], 1], [[["1.0", 0.0, 1.0, 1.0], 2], [[["1.0", 2.0, "?", "?"], 1], [[["0.0", 0.0, 1.0, 2.0], 1], [[["?", 2.0, "?", "?"], 1], [[["0.0", 0.0, "?", "?"], 2], [[["1.0", 0.0, "?", 0.0], 1], [[["?", "?", 1.0, 2.0], 1], [[["0.0",

"?", 1.0, 0.0], 1], [{"?", "?", 0.0, 0.0}], 2], [{"?", 0.0, 0.0, 0.0}], 4], [{"0.0, 0.0, 0.0, 0.0}], 4], [{"0.0, 1.0, 0.0, 0.0}], 1]]

["a2", "a20", "a69"]
[[{"0.0, "?", 0.0, 0.0}], 3], [{"1.0, "?", 1.0, 1.0}], 1], [{"1.0, 1.0, "?", 0.0}], 1], [{"1.0, 0.0, "?", "?"], 1], [{"1.0, 0.0, 0.0, 1.0}], 1], [{"?", 1.0, 1.0, 2.0}], 1], [{"?", "?", "?", "?"], 2], [{"0.0, 1.0, 1.0, 2.0}], 1], [{"?", 1.0, 0.0, 0.0}], 3], [{"0.0, 1.0, "?", "?"], 2], [{"1.0, 1.0, 1.0, 1.0}], 2], [{"0.0, "?", 1.0, 0.0}], 1], [{"0.0, 0.0, 0.0, 0.0}], 2], [{"?", 0.0, 0.0, 0.0}], 3], [{"0.0, 1.0, 0.0, 0.0}], 1]]

["a2", "a21", "a69"]
[[{"?", 0.0, 1.0, 2.0}], 1], [{"?", 2.0, 0.0, 0.0}], 2], [{"0.0, "?", 0.0, 0.0}], 2], [{"0.0, 2.0, 0.0, 0.0}], 1], [{"1.0, 2.0, 1.0, 1.0}], 1], [{"1.0, "?", 1.0, 1.0}], 2], [{"1.0, 0.0, 0.0, 1.0}], 1], [{"1.0, "?", "?", 0.0}], 1], [{"?", "?", "?", "?"], 2], [{"0.0, 2.0, "?", "?"], 1], [{"0.0, 1.0, 1.0, 2.0}], 1], [{"1.0, 2.0, "?", "?"], 1], [{"?", 1.0, 0.0, 0.0}], 1], [{"0.0, 1.0, "?", "?"], 1], [{"?", 0.0, 0.0, 0.0}], 2], [{"?", "?", 0.0, 0.0}], 1], [{"0.0, "?", 1.0, 0.0}], 1], [{"0.0, 0.0, 0.0, 0.0}], 3]]

["a2", "a22", "a69"]
[[{"1.0, 2.0, 0.0, 1.0}], 1], [{"0.0, 2.0, 1.0, 0.0}], 1], [{"0.0, "?", "?", "?"], 1], [{"0.0, 2.0, 0.0, 0.0}], 1], [{"?", 0.0, 2.0, 0.0, 0.0}], 2], [{"0.0, "?", 0.0, 0.0}], 1], [{"?", 2.0, 1.0, 2.0}], 1], [{"1.0, 0.0, 1.0, 1.0}], 2], [{"1.0, 2.0, "?", "?"], 1], [{"0.0, 0.0, "?", "?"], 1], [{"1.0, 9.0, 1.0, 1.0}], 1], [{"0.0, 0.0, 1.0, 2.0}], 1], [{"?", 2.0, "?", "?"], 1], [{"?", 1.0, 0.0, 0.0}], 1], [{"1.0, 0.0, "?", 0.0}], 1], [{"?", 0.0, "?", "?"], 1], [{"?", 0.0, 0.0, 0.0}], 2], [{"?", "?", 0.0, 0.0}], 1], [{"0.0, 0.0, 0.0}], 2]]

["a2", "a23", "a69"]
[[{"0.0, "?", "?", "?"], 1], [{"0.0, "?", 0.0, 0.0}], 1], [{"1.0, "?", 1.0, 1.0}], 1], [{"1.0, 1.0, "?", 0.0}], 1], [{"1.0, 0.0, 0.0, "?", "?"], 1], [{"1.0, 0.0, 0.0, 1.0}], 1], [{"1.0, 0.0, 1.0, 1.0}], 2], [{"0.0, 0.0, "?", "?"], 1], [{"0.0, 0.0, 1.0, 2.0}], 1], [{"0.0, 0.0, 1.0, 2.0}], 1], [{"?", 1.0, 2.0}], 1], [{"0.0, "?", 1.0, 0.0}], 1], [{"?", "?", 0.0, 0.0}], 2], [{"?", 0.0, "?", "?"], 2], [{"?", 0.0, 0.0, 0.0}], 4], [{"0.0, 0.0, 0.0, 0.0}], 4], [{"0.0, 1.0, 0.0, 0.0}], 1]]

["a2", "a25", "a69"]
[[{"0.0, "?", "?", "?"], 1], [{"0.0, "?", 0.0, 0.0}], 1], [{"1.0, "?", 1.0, 1.0}], 1], [{"1.0, 1.0, "?", 0.0}], 1], [{"1.0, 0.0, "?", "?"], 1], [{"1.0, 0.0, 0.0, 1.0}], 1], [{"1.0, 0.0, 1.0, 1.0}], 2], [{"0.0, 0.0, "?", "?"], 1], [{"0.0, 0.0, 1.0, 2.0}], 1], [{"0.0, 0.0, 1.0, 2.0}], 1], [{"?", 1.0, 2.0}], 1], [{"0.0, "?", 1.0, 0.0}], 1], [{"?", 0.0, 0.0}], 2], [{"?", 0.0, "?", "?"], 2], [{"?", 0.0, 0.0, 0.0}], 4], [{"0.0, 0.0, 0.0, 0.0}], 4], [{"0.0, 1.0, 0.0, 0.0}], 1]]

["a2", "a51", "a69"]
[[{"?", 2.0, 0.0, 0.0}], 4], [{"0.0, 2.0, 0.0, 0.0}], 1], [{"1.0, 1.0, "?", 0.0}], 1], [{"0.0, 2.0, "?", "?"], 1], [{"?", 1.0, 1.0, 2.0}], 1], [{"?", 1.0, "?", "?"], 1], [{"1.0, 2.0, "?", "?"], 1], [{"0.0, 1.0, 1.0, 0.0}], 1], [{"?", 2.0, "?", "?"], 1], [{"?", 1.0, 0.0, 0.0}], 2], [{"0.0, 0.0, "?", "?"], 1], [{"1.0, 1.0, 1.0, 1.0}], 3], [{"1.0, 1.0, 0.0, 1.0}], 1], [{"0.0, 2.0, 1.0, 2.0}], 1], [{"0.0, 0.0, 0.0, 0.0}], 1], [{"0.0, 1.0, 0.0, 0.0}], 4]]

["a2", "a56", "a69"]
[[{"1.0, 1.0, "?", 0.0}], 1], [{"1.0, 0.0, "?", "?"], 1], [{"1.0, 0.0, 0.0, 1.0}], 1], [{"?", 1.0, 1.0, 2.0}], 1], [{"0.0, 1.0, 1.0, 2.0}], 1], [{"?", 1.0, "?", "?"], 1], [{"1.0, 0.0, 1.0, 1.0}], 2], [{"?", 1.0, 0.0, 0.0}], 3], [{"0.0, 0.0, "?", "?"], 1], [{"0.0, 1.0, "?", "?"], 1], [{"1.0, 1.0, 1.0, 1.0}], 1], [{"0.0, 0.0, 1.0, 0.0}], 1], [{"?", 0.0, "?", "?"], 1], [{"?", 0.0, 0.0, 0.0}], 3], [{"0.0, 0.0, 0.0, 0.0}], 5], [{"0.0, 1.0, 0.0, 0.0}], 1]]

["a2", "a69", "a72"]
[[{"0.0, "?", "?", "?"], 2], [{"0.0, 1.0, "?", 2.0}], 1], [{"?", 0.0, 1.0, 0.0}], 2], [{"1.0, 0.0, 0.0, 1.0}], 1], [{"?", "?", "?", "?"], 2], [{"1.0, "?", 1.0, 0.0}], 1], [{"1.0, 1.0, 0.0, 1.0}], 3], [{"?", 1.0, 0.0, 2.0}], 1], [{"0.0, 0.0, 1.0, 0.0}], 1], [{"?", 0.0, 0.0, 0.0}], 4], [{"0.0, 0.0, 0.0, 0.0}], 5], [{"0.0, 1.0, 0.0, 0.0}], 1], [{"1.0, "?", "?", "?"], 1]]

["a3", "a4", "a69"]
[[{"0.0, "?", "?", "?"], 2], [{"0.0, 1.0, "?", 0.0}], 1], [{"0.0, "?", 0.0, 0.0}], 2], [{"1.0, 1.0, "?", "?"], 1], [{"0.0, 0.0, 1.0, 2.0}], 1], [{"?", 1.0, 0.0, 0.0}], 2], [{"0.0, 1.0, 1.0, 0.0}], 1], [{"0.0, 0.0, "?", "?"], 1], [{"1.0, 1.0, 1.0, 1.0}], 3], [{"1.0, 1.0, 0.0, 1.0}], 1], [{"?", "?", 1.0, 2.0}], 1], [{"?", "?", 0.0, 0.0}], 3], [{"0.0, 0.0, 0.0, 0.0}], 5], [{"1.0, "?", "?", "?"], 1]]

["a3", "a12", "a69"]
[[{"0.0, "?", "?", "?"], 1], [{"0.0, 1.0, "?", 0.0}], 1], [{"0.0, "?", 0.0, 0.0}], 1], [{"1.0, "?", 1.0, 1.0}], 1], [{"1.0, 0.0, 0.0, "?", "?"], 2], [{"1.0, 0.0, 0.0, 1.0}], 1], [{"0.0, 0.0, 1.0, 2.0}], 1], [{"?", 1.0, 0.0, 0.0}], 1], [{"0.0, 0.0, "?", "?"], 2], [{"1.0, 1.0, 1.0, 1.0}], 2], [{"?", "?", 1.0, 2.0}], 1], [{"0.0, "?", 1.0, 0.0}], 1], [{"?", "?", 0.0, 0.0}], 2], [{"?", 0.0, 0.0, 0.0}], 2], [{"0.0, 0.0, 0.0, 0.0}], 5], [{"0.0, 1.0, 0.0, 0.0}], 1]]

["a3", "a23", "a69"]
[[{"0.0, 1.0, "?", 0.0}], 1], [{"0.0, "?", "?", "?"], 1], [{"0.0, "?", 0.0, 0.0}], 1], [{"1.0, "?", 1.0, 1.0}], 1], [{"1.0, 0.0, "?", "?"], 2], [{"1.0, 0.0, 0.0, 1.0}], 1], [{"1.0, 0.0, 1.0, 1.0}], 2], [{"0.0, 0.0,

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"?", "?", 2], [[0.0, 0.0, 1.0, 2.0], 1], [{"?", "?", 1.0, 2.0], 1], [[0.0, "?", 1.0, 0.0], 1], [{"?",
"?", 0.0, 0.0], 2], [{"?", 0.0, 0.0, 0.0], 3], [[0.0, 0.0, 0.0, 0.0], 5], [[0.0, 1.0, 0.0, 0.0], 1]]

["a3", "a25", "a69"]
[[[0.0, 1.0, "?", 0.0], 1], [[0.0, "?", "?", "?"], 1], [[0.0, "?", 0.0, 0.0], 1], [[1.0, "?", 1.0,
1.0], 1], [[1.0, 0.0, "?", "?"], 2], [[1.0, 0.0, 0.0, 1.0], 1], [[1.0, 0.0, 1.0, 1.0], 2], [[0.0, 0.0,
"?", "?"], 2], [[0.0, 0.0, 1.0, 2.0], 1], [{"?", "?", 1.0, 2.0], 1], [[0.0, "?", 1.0, 0.0], 1], [{"?",
"?", 0.0, 0.0], 2], [{"?", 0.0, 0.0, 0.0], 3], [[0.0, 0.0, 0.0, 0.0], 5], [[0.0, 1.0, 0.0, 0.0], 1]]

["a3", "a61", "a69"]
[[["?", 0.0, 1.0, 2.0], 1], [[0.0, 1.0, "?", 0.0], 1], [[1.0, 1.0, "?", "?"], 2], [[1.0, 0.0, 1.0,
1.0], 3], [[0.0, 0.0, 1.0, 2.0], 1], [[0.0, 1.0, 1.0, 0.0], 1], [{"?", 1.0, 0.0, 0.0], 1], [[0.0, 0.0,
"?", "?"], 3], [[1.0, 1.0, 0.0, 1.0], 1], [{"?", "?", 0.0, 0.0], 2], [{"?", 0.0, 0.0, 0.0], 2], [[0.0,
0.0, 0.0, 0.0], 4], [[0.0, 1.0, 0.0, 0.0], 3]]

["a3", "a69", "a72"]
[[[0.0, "?", "?", "?"], 3], [[0.0, 1.0, "?", 2.0], 1], [{"?", 0.0, 1.0, 0.0], 2], [[1.0, 0.0, 0.0,
1.0], 1], [[1.0, 1.0, 0.0, 1.0], 3], [{"?", 1.0, 0.0, 2.0], 1], [[0.0, 0.0, 1.0, 0.0], 1], [[0.0, "?",
1.0, 0.0], 1], [{"?", 0.0, 0.0, 0.0], 3], [[0.0, 0.0, 0.0, 0.0], 6], [[0.0, 1.0, 0.0, 0.0], 1], [[1.0,
"?", "?", "?"], 2]]

["a4", "a22", "a69"]
[[[1.0, 2.0, 0.0, 1.0], 1], [[1.0, 2.0, 1.0, 0.0], 1], [[0.0, "?", "?", "?"], 1], [[0.0, 2.0, 0.0,
0.0], 1], [{"?", 2.0, 0.0, 0.0], 2], [[0.0, "?", 0.0, 0.0], 1], [{"?", 2.0, 1.0, 2.0], 1], [[1.0, 0.0,
0.0, 0.0], 2], [[1.0, 0.0, 1.0, 1.0], 2], [[1.0, 2.0, "?", "?"], 1], [[1.0, 9.0, 1.0, 1.0], 1], [[0.0,
0.0, 1.0, 2.0], 1], [{"?", 2.0, "?", "?"], 1], [{"?", 1.0, 0.0, 0.0], 1], [[1.0, 0.0, "?", 0.0], 1],
[["?", 0.0, "?", "?"], 2], [{"?", 0.0, 0.0, 0.0], 1], [{"?", "?", 0.0, 0.0], 1], [[0.0, 0.0, 0.0,
0.0], 1], [[0.0, 1.0, 0.0, 0.0], 2]]

["a5", "a22", "a69"]
[[[1.0, 2.0, 0.0, 1.0], 1], [[1.0, 2.0, 1.0, 0.0], 1], [[0.0, "?", "?", "?"], 1], [[0.0, 2.0, 0.0,
0.0], 1], [{"?", 2.0, 0.0, 0.0], 2], [[0.0, "?", 0.0, 0.0], 1], [{"?", 2.0, 1.0, 2.0], 1], [[1.0, 0.0,
0.0, 0.0], 2], [[1.0, 0.0, 1.0, 1.0], 2], [[1.0, 2.0, "?", "?"], 2], [[1.0, 9.0, 1.0, 1.0], 1], [[0.0,
0.0, 1.0, 2.0], 1], [{"?", 1.0, 0.0, 0.0], 1], [[0.0, 0.0, "?", 0.0], 1], [{"?", 0.0, "?", "?"], 2],
[["?", "?", 0.0, 0.0], 1], [[0.0, 0.0, 0.0, 0.0], 2], [[0.0, 1.0, 0.0, 0.0], 2]]

["a5", "a61", "a69"]
[[["?", 0.0, 1.0, 2.0], 1], [[0.0, 1.0, "?", 0.0], 1], [[1.0, "?", 0.0, 0.0], 2], [[1.0, 1.0, "?",
"?", 2], [[1.0, 0.0, 1.0, 1.0], 3], [[0.0, 0.0, 1.0, 2.0], 1], [{"?", 1.0, 0.0, 0.0], 2], [[0.0, 0.0,
"?", "?"], 1], [[1.0, 1.0, 0.0, 1.0], 1], [{"?", 0.0, "?", "?"], 2], [[1.0, 1.0, 1.0, 0.0], 1], [{"?",
0.0, 0.0, 0.0], 2], [[0.0, 0.0, 0.0, 0.0], 4], [[0.0, 1.0, 0.0, 0.0], 2]]

```

Even with a limit of 3 attributes to be considered for coverings, the Large Test Dataset still produced a massive amount of coverings and rules for those coverings (increasing the limit on attributes considered for coverings from 3 to 4 would have increased the length of the output in this document by about 290 pages). This is far too much data to process manually, however, enabling pruning with the same option set used for this test case should be sufficient to verify the results.

Large Test Dataset – Test Case #2

- Single decision attribute
- Number of attributes considered for coverings limited to 3
- No minimum instance coverage for reported rules
- Redundant rules pruned

Attributes to partition on: ["a0", "a1", "a2", "a3", "a4", "a5", "a6", "a7", "a8", "a9", "a10", "a11", "a12", "a13", "a14", "a15", "a16", "a17", "a18", "a19", "a20", "a21", "a22", "a23", "a24", "a25", "a26", "a27", "a28", "a29", "a30", "a31", "a32", "a33", "a34", "a35", "a36", "a37", "a38", "a39", "a40", "a41", "a42", "a43", "a44", "a45", "a46", "a47", "a48", "a49", "a50", "a51", "a52", "a53", "a54", "a55", "a56", "a57", "a58", "a59", "a60", "a61", "a62", "a63", "a64", "a65", "a66", "a67", "a68", "a69", "a70", "a72", "a73", "a74", "a75", "a76", "a77"]

Decision attributes: ["a71"]
Value: [2.0] Occurrences: 2
Value: [1.0] Occurrences: 4
Value: [0.0] Occurrences: 14
Value: ["?"] Occurrences: 5

Coverings:

["a0", "a2", "a69"]
[[["?", "-", "0.0, 0.0", 4], [{"?", "-", "?", "?"}, 1], [{"-", "?", "?", "?"}, 2], [{"1.0, 0.0, "-", 0.0}, 1], [{"1.0, "-", "?", "?"}, 1], [{"0.0, 1.0, "-", 0.0}, 1], [{"?", "-", 1.0, 2.0}, 1], [{"0.0, "-", 1.0, 2.0}, 1], [{"-", "0.0, ?", "?"}, 1], [{"-", "1.0, 1.0, 1.0}, 3], [{"-", "1.0, 0.0, 1.0}, 1], [{"0.0, "-", "0.0, 0.0}, 6], [{"-", "?", "0.0, 0.0}, 2]]

["a0", "a61", "a69"]
[[["?", "-", "0.0, 0.0", 4], [{"?", "-", "?", "?"}, 1], [{"1.0, "-", "?", "?"}, 2], [{"1.0, 0.0, "-", 1.0}, 3], [{"0.0, 1.0, "-", 0.0}, 3], [{"?", "-", 1.0, 2.0}, 1], [{"0.0, "-", 1.0, 2.0}, 1], [{"-", "0.0, ?", "?"}, 2], [{"1.0, 1.0, 0.0, 1.0}, 1], [{"-", "1.0, 1.0, 0.0}, 1], [{"0.0, "-", "0.0, 0.0}, 4], [{"-", "?", "0.0, 2]]

["a1", "a61", "a69"]
[[["?", "-", "0.0, 0.0", 4], [{"1.0, "-", "?", "?"}, 2], [{"1.0, 0.0, "-", 1.0}, 3], [{"0.0, 1.0, "-", 0.0}, 4], [{"?", "-", 1.0, 2.0}, 1], [{"0.0, 0.0, 1.0, 2.0}, 1], [{"-", "0.0, ?", "?"}, 3], [{"1.0, 1.0, 0.0, 1.0}, 1], [{"0.0, "-", "0.0, 0.0}, 4], [{"-", "?", "-", "0.0}, 2]]

["a1", "a69", "a72"]
[[["?", "0.0, "-", "0.0", 4], [{"-", "?", "?", "?"}, 5], [{"1.0, "-", "0.0, 1.0}, 4], [{"?", "1.0, "-", 2.0}, 1], [{"-", "1.0, 0.0}, 3], [{"-", "1.0, ?", 2.0}, 1], [{"0.0, 0.0, "-", "0.0}, 6], [{"0.0, "-", "0.0, 0.0}, 1]]

["a2", "a5", "a69"]
[[["?", "-", "0.0, 0.0", 6], [{"0.0, "?", "-", "?"}, 1], [{"1.0, 0.0, "-", "0.0}, 1], [{"-", "1.0, ?", "?", 2], [{"?", "-", 1.0, 2.0}, 1], [{"-", "0.0, 1.0, 2.0}, 1], [{"0.0, 1.0, "-", "0.0}, 1], [{"0.0, "-", "?", "?", 1], [{"1.0, "-", 1.0, 1.0}, 3], [{"1.0, "-", "0.0, 1.0}, 1], [{"?", "-", "?", "?"}, 1], [{"0.0, "-", "0.0, 0.0}, 6]]

["a2", "a8", "a69"]
[[["?", "0.0, "-", "0.0", 1], [{"?", "-", "0.0, 0.0", 5], [{"0.0, "-", "?", "?"}, 2], [{"0.0, 1.0, 1.0, 2.0}, 1], [{"?", "-", 1.0, 2.0}, 1], [{"?", "-", "?", "?"}, 2], [{"1.0, "-", 1.0, 1.0}, 3], [{"1.0, "-", "0.0, 1.0}, 1], [{"-", "0.0, 1.0, 0.0}, 1], [{"1.0, 1.0, "?", "0.0}, 1], [{"0.0, "-", "0.0, 0.0}, 6], [{"1.0, 0.0, "-", "?", 1]]

["a2", "a12", "a69"]
[[["?", "-", "0.0, 0.0", 6], [{"?", "-", "?", "?"}, 2], [{"1.0, "-", "0.0, 1.0}, 1], [{"?", "-", 1.0, 2.0}, 1], [{"-", "0.0, 1.0, 2.0}, 1], [{"0.0, "-", "?", "?"}, 2], [{"1.0, "-", 1.0, 1.0}, 3], [{"0.0, "-", "1.0, 1.0}, 3], [{"0.0, "?", "-", "0.0}, 2], [{"-", "1.0, ?", "0.0}, 1], [{"0.0, "-", "0.0, 0.0}, 5], [{"-", "0.0, ?", "?"}, 1]]

["a2", "a16", "a69"]
[[["?", "-", "0.0, 0.0", 6], [{"1.0, 0.0, "?", "0.0}, 1], [{"1.0, "-", "0.0, 1.0}, 1], [{"-", "2.0, "-", "?", 2], [{"1.0, "-", 1.0, 1.0}, 3], [{"?", "-", "1.0, 2.0}, 1], [{"0.0, 0.0, 1.0, 2.0}, 1], [{"0.0, "-", "?", "?", 2], [{"0.0, "?", "-", "0.0}, 2], [{"?", "-", "?", "?"}, 1], [{"0.0, "-", "0.0, 0.0}, 5]]

["a2", "a20", "a69"]
[[["?", "0.0, "-", "0.0}, 3], [{"?", "-", "0.0, 0.0}, 3], [{"1.0, "-", "0.0, 1.0}, 1], [{"0.0, "-", "?", "?", 2], [{"0.0, 1.0, 1.0, 2.0}, 1], [{"?", "-", 1.0, 2.0}, 1], [{"1.0, "-", 1.0, 1.0}, 3], [{"0.0, "?", "-", "0.0}, 4], [{"1.0, 1.0, "?", "0.0}, 1], [{"0.0, 0.0, "-", "0.0}, 2], [{"?", "?", "-", "?"}, 2], [{"-", "?", 2]]

0.0, "?", "?", 1], [[0.0, "_", 0.0, 0.0], 1]]

["a2", "a21", "a69"]
[[["?", "_", 0.0, 0.0], 6], [[0.0, "_", 0.0, 0.0], 6], [[1.0, "_", 1.0, 1.0], 3], [[0.0, "_", "?", "?", 2], [[1.0, 0.0, "_", 1.0], 1], [["_", 1.0, 1.0, 2.0], 1], [["?", " ", 1.0, 2.0], 1], [["_", 2.0, "?", "?", 1], [[0.0, "?", "_", 0.0], 1], [[1.0, "?", "?", 0.0], 1], [["?", "_", "?", "?", 2]]

["a2", "a22", "a69"]
[[[1.0, "_", 0.0, 1.0], 1], [["?", "_", 0.0, 0.0], 6], [[0.0, 2.0, "_", 0.0], 2], [["?", "_", "?", "?", 2], [[0.0, "_", "?", "?", 2], [[1.0, 0.0, "?", 0.0], 1], [[1.0, "_", 1.0, 1.0], 3], [[0.0, 0.0, 1.0, 2.0], 1], [["_", 2.0, "?", "?", 1], [["?", "_", 1.0, 2.0], 1], [[0.0, "_", 0.0, 0.0], 5]]

["a2", "a23", "a69"]
[[["?", "_", 0.0, 0.0], 6], [["?", "_", "?", "?", 2], [[0.0, "_", "?", "?", 2], [[1.0, "_", 0.0, 1.0], 1], [[1.0, "_", 1.0, 1.0], 3], [["?", "_", 1.0, 2.0], 1], [[0.0, 0.0, 1.0, 2.0], 1], [[0.0, "?", 1.0, 0.0], 1], [["_", 1.0, "_", 0.0], 2], [[0.0, "_", 0.0, 0.0], 5], [["_", 0.0, "?", "?", 1]]

["a2", "a25", "a69"]
[[["?", "_", 0.0, 0.0], 6], [["?", "_", "?", "?", 2], [[0.0, "_", "?", "?", 2], [[1.0, "_", 0.0, 1.0], 1], [[1.0, "_", 1.0, 1.0], 3], [["?", "_", 1.0, 2.0], 1], [[0.0, 0.0, 1.0, 2.0], 1], [[0.0, "?", 1.0, 0.0], 1], [["_", 1.0, "_", 0.0], 2], [[0.0, "_", 0.0, 0.0], 5], [["_", 0.0, "?", "?", 1]]

["a2", "a51", "a69"]
[[[0.0, "_", 0.0, 0.0], 6], [["?", "_", 0.0, 0.0], 6], [["?", "_", "?", "?", 2], [["?", "_", 1.0, 2.0], 1], [[0.0, 1.0, "_", 0.0], 1], [[1.0, 2.0, "_", "?", 1], [[0.0, " ", "?", "?", 2], [[1.0, "_", 1.0, 1.0], 3], [[1.0, "_", 0.0, 1.0], 1], [[1.0, 1.0, "?", 0.0], 1], [["_", 2.0, 1.0, 2.0], 1]]

["a2", "a56", "a69"]
[[["?", "_", 0.0, 0.0], 6], [["?", "_", "?", "?", 2], [[0.0, "_", "?", "?", 2], [[1.0, "_", 0.0, 1.0], 1], [[0.0, 1.0, 1.0, 2.0], 1], [[1.0, "_", 1.0, 1.0], 3], [["?", "_", 1.0, 2.0], 1], [[0.0, 0.0, 1.0, 0.0], 1], [[1.0, 1.0, "?", 0.0], 1], [[0.0, "_", 0.0, 0.0], 6], [["_", 0.0, "?", "?", 1]]

["a2", "a69", "a72"]
[[["?", 0.0, "_", 0.0], 6], [[0.0, "?", " ", "?", 2], [[1.0, 0.0, "_", 1.0], 1], [["?", 1.0, "_", 2.0], 1], [["_", " ", 1.0, 0.0], 2], [["_", 1.0, "?", 2.0], 1], [[1.0, "_", "?", "?", 1], [[1.0, 1.0, "_", 1.0], 3], [["?", "?", "_", "?", 2], [[0.0, 0.0, "_", 0.0], 5], [[0.0, "_", 0.0, 0.0], 1]]

["a3", "a4", "a69"]
[[["?", "_", 0.0, 0.0], 5], [["_", "?", "?", "?", 3], [[1.0, "_", "?", "?", 1], [[0.0, 1.0, "_", 0.0], 2], [["?", "_", 1.0, 2.0], 1], [["_", 0.0, 1.0, 2.0], 1], [["_", 0.0, "?", "?", 1], [[1.0, "_", 1.0, 1.0], 3], [[1.0, "_", 0.0, 1.0], 1], [[0.0, "_", 0.0, 0.0], 7]]

["a3", "a12", "a69"]
[[["?", "_", 0.0, 0.0], 5], [["_", "?", "?", "?", 1], [[1.0, "_", 0.0, 1.0], 1], [[0.0, 1.0, "_", 0.0], 2], [["?", "_", 1.0, 2.0], 1], [["_", 0.0, 1.0, 2.0], 1], [["_", 0.0, "?", "?", 4], [[1.0, 1.0, "_", 1.0], 2], [[0.0, "?", 1.0, 0.0], 1], [[0.0, "_", 0.0, 0.0], 6], [[1.0, "?", "_", 1.0], 1]]

["a3", "a23", "a69"]
[[["?", "_", 0.0, 0.0], 5], [["_", "?", "?", "?", 1], [[1.0, "_", 0.0, 1.0], 1], [[1.0, "_", 1.0, 1.0], 3], [["_", 1.0, "_", 0.0], 2], [["?", "_", 1.0, 2.0], 1], [[0.0, 0.0, 1.0, 2.0], 1], [["_", 0.0, "?", "?", 4], [[0.0, "?", 1.0, 0.0], 1], [[0.0, "_", 0.0, 0.0], 6]]

["a3", "a25", "a69"]
[[["?", "_", 0.0, 0.0], 5], [["_", "?", "?", "?", 1], [[1.0, "_", 0.0, 1.0], 1], [[1.0, "_", 1.0, 1.0], 3], [["_", 1.0, " ", 0.0], 2], [["?", "_", 1.0, 2.0], 1], [[0.0, 0.0, 1.0, 2.0], 1], [["_", 0.0, "?", "?", 4], [[0.0, "?", 1.0, 0.0], 1], [[0.0, "_", 0.0, 0.0], 6]]

["a3", "a61", "a69"]
[[["?", "?", "_", 0.0], 2], [["?", "_", 0.0, 0.0], 3], [[1.0, "_", "?", "?", 2], [[1.0, 0.0, "_", 1.0], 3], [[0.0, 1.0, "_", 0.0], 5], [["?", "_", 1.0, 2.0], 1], [[0.0, 0.0, 1.0, 2.0], 1], [["_", 0.0, "?", "?", 3], [[1.0, "_", 0.0, 1.0], 1], [[0.0, "_", 0.0, 0.0], 4]]

["a3", "a69", "a72"]
[[["?", 0.0, "_", 0.0], 5], [["_", "?", "?", "?", 5], [[1.0, 0.0, "_", 1.0], 1], [["?", 1.0, "_", 2.0], 1], [["_", 1.0, "?", 2.0], 1], [[1.0, 1.0, "_", 1.0], 3], [["_", "_", 1.0, 0.0], 2], [[0.0, 0.0, "_", 0.0], 6], [[0.0, "_", 0.0, 0.0], 1]]

["a4", "a22", "a69"]
[[[1.0, 2.0, 0.0, 1.0], 1], [[1.0, 2.0, 1.0, 0.0], 1], [["?", "_", 0.0, 0.0], 5], [["?", "_", "?", "?", 3], [[0.0, 2.0, "_", 0.0], 1], [[0.0, "_", "?", "?", 1], [[1.0, 0.0, "?", 0.0], 1], [["_", 0.0, 0.0, 0.0], 3], [[1.0, 0.0, 1.0, 1.0], 2], [["_", 9.0, " ", 1.0], 1], [[0.0, "_", 1.0, 2.0], 1], [["_", 2.0, "?", "?", 1], [["?", "_", 1.0, 2.0], 1], [[0.0, "_", 0.0, 0.0], 3]]

["a5", "a22", "a69"]

```

[[[1.0, 2.0, 0.0, 1.0], 1], [[1.0, 2.0, 1.0, 0.0], 1], [[ "?", "?", "_", 0.0], 1], [[ "?", 0.0, "_", "?", 2], [[0.0, 2.0, "_", 0.0], 1], [[0.0, 0.0, "?", 0.0], 1], [[ "_", 1.0, "_", 0.0], 3], [[ "_", "?", "?", "?", 1], [[ "?", "_", 0.0, 0.0], 2], [[ "_", 0.0, 0.0, 0.0], 4], [[1.0, 0.0, 1.0, 1.0], 2], [[ "_", 9.0, "_", 1.0], 1], [[0.0, "_", 1.0, 2.0], 1], [[1.0, "_", "?", "?", 2], [[ "?", "_", 1.0, 2.0], 1], [[0.0, "_", 0.0, 0.0], 1]]

["a5", "a61", "a69"]
[[[ "?", "_", 0.0, 0.0], 4], [[ "?", "_", "?", "?", 2], [[1.0, "_", "?", "?", 2], [[1.0, 0.0, "_", 1.0], 3], [[0.0, 1.0, "_", 0.0], 3], [[ "?", "_", 1.0, 2.0], 1], [[0.0, "_", 1.0, 2.0], 1], [[ "_", 0.0, "?", "?", 1], [[1.0, 1.0, 0.0, 1.0], 1], [[ "_", 1.0, 1.0, 0.0], 1], [[0.0, "_", 0.0, 0.0], 4], [[ "_", "?", "_", 0.0], 2]]

```

Consider the following rules produced from the following covering in the unpruned test results:

```

["a0", "a2", "a69"]
[[0.0, 0.0, 0.0, 0.0], 5], [[0.0, "?", 0.0, 0.0], 1]

```

Notice how the condition on the antecedent a2 was removed during the pruning process and the rules were combined in the pruned test results:

```

["a0", "a2", "a69"]
[[0.0, "_", 0.0, 0.0], 6]

```

Further examination of the results of the unpruned and pruned tests for the Large Test Dataset will show that the rules induced from the coverings are correctly combined when pruning is enabled.

Large Test Dataset – Test Case #3

- Multiple decision attributes
- Number of attributes considered for coverings limited to 3
- No minimum instance coverage for reported rules
- Redundant rules not pruned

Attributes to partition on: ["a0", "a1", "a2", "a3", "a4", "a5", "a6", "a7", "a8", "a9", "a10", "a11", "a12", "a13", "a14", "a15", "a16", "a17", "a18", "a19", "a20", "a21", "a22", "a23", "a24", "a25", "a26", "a27", "a28", "a29", "a30", "a31", "a32", "a33", "a34", "a35", "a36", "a37", "a38", "a39", "a40", "a41", "a42", "a43", "a44", "a45", "a46", "a47", "a48", "a49", "a50", "a51", "a52", "a53", "a54", "a55", "a56", "a57", "a58", "a59", "a60", "a61", "a62", "a63", "a64", "a65", "a66", "a67", "a68", "a69", "a70", "a72", "a73", "a74", "a75", "a76"]

Decision attributes: ["a71"]

Value: [2.0] Occurrences: 2
Value: [1.0] Occurrences: 4
Value: [0.0] Occurrences: 14
Value: ["?"] Occurrences: 5

Decision attributes: ["a77"]

Value: [1.0] Occurrences: 2
Value: [0.0] Occurrences: 23

Decision attributes: ["a71", "a77"]

Value: ["?", 0.0] Occurrences: 5
Value: [2.0, 0.0] Occurrences: 2
Value: [0.0, 1.0] Occurrences: 2
Value: [0.0, 0.0] Occurrences: 12
Value: [1.0, 0.0] Occurrences: 4

Coverings:

["a0", "a2", "a69"]
[[[0.0, 0.0, "?", "?", 0.0], 1], [[0.0, 0.0, 1.0, 2.0, 0.0], 1], [[1.0, 1.0, 0.0, 1.0, 0.0], 1],
[[0.0, "?", "?", "?", 0.0], 1], [[1.0, 0.0, 1.0, 0.0, 0.0], 1], [[1.0, 1.0, 1.0, 1.0, 0.0], 3], [[1.0,
"?", 0.0, 0.0, 1.0], 2], [["?", "?", 0.0, 0.0, 0.0], 3], [[0.0, 0.0, 0.0, 0.0, 0.0], 5], [["?", "?",
1.0, 2.0, 0.0], 1], [[1.0, "?", "?", "?", 0.0], 1], [["?", 0.0, "?", "?", 0.0], 1], [[1.0, 1.0, "?",
"?", 0.0], 1], [[0.0, "?", 0.0, 0.0, 0.0], 1], [["?", 0.0, 0.0, 0.0, 0.0], 1], [[0.0, 1.0, "?", 0.0,
0.0], 1]]

["a0", "a61", "a69"]
[[[0.0, 0.0, "?", "?", 0.0], 2], [[0.0, 0.0, 1.0, 2.0, 0.0], 1], [[1.0, 1.0, 0.0, 1.0, 0.0], 1],
[["?", 0.0, 1.0, 2.0, 0.0], 1], [[1.0, "?", 0.0, 0.0, 1.0], 2], [[0.0, 0.0, 0.0, 0.0, 0.0], 4], [["?",
0.0, "?", "?", 0.0], 1], [[1.0, 1.0, 1.0, 0.0, 0.0], 1], [["?", 1.0, 0.0, 0.0, 0.0], 2], [[1.0, 1.0,
"?", "?", 0.0], 2], [[1.0, 0.0, 1.0, 1.0, 0.0], 3], [["?", 0.0, 0.0, 0.0, 0.0], 2], [[0.0, 1.0, 0.0,
0.0, 0.0], 2], [[0.0, 1.0, "?", 0.0, 0.0], 1]]

["a1", "a61", "a69"]
[[[0.0, 1.0, 1.0, 0.0, 0.0], 1], [[0.0, 0.0, "?", "?", 0.0], 3], [[0.0, 0.0, 1.0, 2.0, 0.0], 1],
[[1.0, 1.0, 0.0, 1.0, 0.0], 1], [["?", 0.0, 1.0, 2.0, 0.0], 1], [[1.0, "?", 0.0, 0.0, 1.0], 2], [[0.0,
0.0, 0.0, 0.0, 0.0], 4], [["?", 1.0, 0.0, 0.0, 0.0], 2], [[1.0, 1.0, "?", "?", 0.0], 2], [[1.0, 0.0,
1.0, 1.0, 0.0], 3], [["?", 0.0, 0.0, 0.0, 0.0], 2], [[0.0, 1.0, 0.0, 0.0, 0.0], 2], [[0.0, 1.0, "?",
0.0, 0.0], 1]]

["a1", "a69", "a72"]
[[["?", 1.0, 0.0, 2.0, 0.0], 1], [[0.0, "?", 1.0, 0.0, 0.0], 1], [[0.0, 1.0, "?", 2.0, 0.0], 1],
[[1.0, 1.0, 0.0, 1.0, 0.0], 3], [[1.0, 0.0, 1.0, 0.0, 1.0], 2], [[0.0, "?", "?", "?", 0.0], 3], [[0.0,
0.0, 0.0, 0.0, 0.0], 6], [[1.0, 0.0, 0.0, 1.0, 0.0], 1], [[1.0, "?", "?", "?", 0.0], 2], [["?", 0.0,
1.0, 0.0, 0.0], 1], [["?", 0.0, 0.0, 0.0, 0.0], 3], [[0.0, 1.0, 0.0, 0.0, 0.0], 1]]

["a2", "a5", "a69"]
[[[0.0, 1.0, 1.0, 0.0, 0.0], 1], [[0.0, 0.0, "?", "?", 0.0], 1], [[0.0, 0.0, 1.0, 2.0, 0.0], 1],
[[1.0, 1.0, 0.0, 1.0, 0.0], 1], [[0.0, "?", "?", "?", 0.0], 1], [[1.0, 1.0, 1.0, 1.0, 0.0], 3], [["?",
1.0, 0.0, 0.0, 1.0], 2], [["?", "?", 0.0, 0.0, 0.0], 4], [[0.0, 0.0, 0.0, 0.0, 0.0], 6], [["?", "?",
"?", "?", 0.0], 1], [["?", "?", 1.0, 2.0, 0.0], 1], [["?", 1.0, "?", "?", 0.0], 1], [[1.0, 1.0, "?",
"?", 0.0], 1], [[1.0, 0.0, "?", 0.0, 0.0], 1]]

["a2", "a22", "a69"]
[[["?", 2.0, 1.0, 2.0, 0.0], 1], [[0.0, 0.0, "?", "?", 0.0], 1], [[1.0, 2.0, 0.0, 1.0, 0.0], 1],
[[0.0, 2.0, 0.0, 0.0, 0.0], 1], [["?", 0.0, 0.0, 0.0, 1.0], 2], [[0.0, 2.0, 1.0, 0.0, 0.0], 1], [[1.0,
9.0, 1.0, 1.0, 0.0], 1], [[0.0, 0.0, 1.0, 2.0, 0.0], 1], [["?", 2.0, "?", "?", 0.0], 1], [["?", 2.0,

```

0.0, 0.0, 0.0], 2], [[0.0, "?", "?", "?", 0.0], 1], [[ "?", "?", 0.0, 0.0, 0.0], 1], [[0.0, 0.0, 0.0,
0.0, 0.0], 2], [[ "?", 0.0, "?", "?", 0.0], 1], [[ "?", 1.0, 0.0, 0.0, 0.0], 1], [[1.0, 0.0, 1.0, 1.0,
0.0], 2], [[1.0, 0.0, "?", 0.0, 0.0], 1], [[1.0, 2.0, "?", "?", 0.0], 1], [[0.0, "?", 0.0, 0.0, 0.0],
1], [[0.0, 1.0, 0.0, 0.0, 0.0], 2]]

["a2", "a69", "a72"]
[[ "?", 1.0, 0.0, 2.0, 0.0], 1], [[1.0, "?", 1.0, 0.0, 0.0], 1], [[0.0, 1.0, "?", 2.0, 0.0], 1],
[[1.0, 1.0, 0.0, 1.0, 0.0], 3], [[ "?", 0.0, 1.0, 0.0, 1.0], 2], [[0.0, "?", "?", "?", 0.0], 2], [[0.0,
0.0, 1.0, 0.0, 0.0], 1], [[0.0, 0.0, 0.0, 0.0, 0.0], 5], [[1.0, 0.0, 0.0, 1.0, 0.0], 1], [[ "?", "?",
 "?", "?", 0.0], 2], [[1.0, "?", "?", "?", 0.0], 1], [[ "?", 0.0, 0.0, 0.0, 0.0], 4], [[0.0, 1.0, 0.0,
0.0, 0.0], 1]]

["a3", "a4", "a69"]
[[[0.0, 1.0, 1.0, 0.0, 0.0], 1], [[0.0, 0.0, "?", "?", 0.0], 1], [[0.0, 0.0, 1.0, 2.0, 0.0], 1],
[[1.0, 1.0, 0.0, 1.0, 0.0], 1], [[0.0, "?", "?", "?", 0.0], 2], [[1.0, 1.0, 1.0, 1.0, 0.0], 3], [[ "?",
1.0, 0.0, 0.0, 1.0], 2], [[ "?", "?", 0.0, 0.0, 0.0], 3], [[0.0, 0.0, 0.0, 0.0, 0.0], 5], [[ "?", "?",
1.0, 2.0, 0.0], 1], [[1.0, "?", "?", "?", 0.0], 1], [[1.0, 1.0, "?", "?", 0.0], 1], [[0.0, "?", 0.0,
0.0, 0.0], 2], [[0.0, 1.0, "?", 0.0, 0.0], 1]]

["a3", "a61", "a69"]
[[[0.0, 1.0, 1.0, 0.0, 0.0], 1], [[0.0, 0.0, "?", "?", 0.0], 3], [[0.0, 0.0, 1.0, 2.0, 0.0], 1],
[[ "?", "?", 0.0, 0.0, 1.0], 2], [[1.0, 1.0, 0.0, 1.0, 0.0], 1], [[ "?", 0.0, 1.0, 2.0, 0.0], 1], [[0.0,
0.0, 0.0, 0.0, 0.0], 4], [[ "?", 1.0, 0.0, 0.0, 0.0], 1], [[1.0, 1.0, "?", "?", 0.0], 2], [[1.0, 0.0,
1.0, 1.0, 0.0], 3], [[ "?", 0.0, 0.0, 0.0, 0.0], 2], [[0.0, 1.0, "?", 0.0, 0.0], 1], [[0.0, 1.0, 0.0,
0.0, 0.0], 3]]

["a3", "a69", "a72"]
[[[ "?", 1.0, 0.0, 2.0, 0.0], 1], [[0.0, "?", 1.0, 0.0, 0.0], 1], [[0.0, 1.0, "?", 2.0, 0.0], 1],
[[1.0, 1.0, 0.0, 1.0, 0.0], 3], [[ "?", 0.0, 1.0, 0.0, 1.0], 2], [[0.0, "?", "?", "?", 0.0], 3], [[0.0,
0.0, 1.0, 0.0, 0.0], 1], [[0.0, 0.0, 0.0, 0.0, 0.0], 6], [[1.0, 0.0, 0.0, 1.0, 0.0], 1], [[1.0, "?",
 "?", "?", 0.0], 2], [[ "?", 0.0, 0.0, 0.0, 0.0], 3], [[0.0, 1.0, 0.0, 0.0, 0.0], 1]]

["a4", "a22", "a69"]
[[[ "?", 2.0, 1.0, 2.0, 0.0], 1], [[1.0, 2.0, 0.0, 1.0, 0.0], 1], [[0.0, 2.0, 0.0, 0.0, 0.0], 1],
[[1.0, 9.0, 1.0, 1.0, 0.0], 1], [[0.0, 0.0, 1.0, 2.0, 0.0], 1], [[ "?", 2.0, "?", "?", 0.0], 1], [[1.0,
0.0, 0.0, 0.0, 1.0], 2], [[ "?", 2.0, 0.0, 0.0, 0.0], 2], [[0.0, "?", "?", "?", 0.0], 1], [[ "?", "?",
0.0, 0.0, 0.0], 1], [[0.0, 0.0, 0.0, 0.0, 0.0], 1], [[ "?", 0.0, "?", "?", 0.0], 2], [[ "?", 1.0, 0.0,
0.0, 0.0], 1], [[1.0, 0.0, 1.0, 1.0, 0.0], 2], [[1.0, 0.0, "?", 0.0, 0.0], 1], [[ "?", 0.0, 0.0, 0.0,
0.0], 1], [[1.0, 2.0, "?", "?", 0.0], 1], [[0.0, "?", 0.0, 0.0, 0.0], 1], [[1.0, 2.0, 1.0, 0.0, 0.0],
1], [[0.0, 1.0, 0.0, 0.0, 0.0], 2]]

["a5", "a22", "a69"]
[[[ "?", 2.0, 1.0, 2.0, 0.0], 1], [[1.0, 2.0, 0.0, 1.0, 0.0], 1], [[0.0, 2.0, 0.0, 0.0, 0.0], 1],
[[1.0, 9.0, 1.0, 1.0, 0.0], 1], [[0.0, 0.0, 1.0, 2.0, 0.0], 1], [[1.0, 0.0, 0.0, 0.0, 1.0], 2], [[ "?",
2.0, 0.0, 0.0, 0.0], 2], [[0.0, "?", "?", "?", 0.0], 1], [[0.0, 0.0, "?", 0.0, 0.0], 1], [[ "?", "?",
0.0, 0.0, 0.0], 1], [[0.0, 0.0, 0.0, 0.0, 0.0], 2], [[ "?", 0.0, "?", "?", 0.0], 2], [[ "?", 1.0, 0.0,
0.0, 0.0], 1], [[1.0, 0.0, 1.0, 1.0, 0.0], 2], [[1.0, 2.0, "?", "?", 0.0], 2], [[0.0, "?", 0.0, 0.0,
0.0], 1], [[1.0, 2.0, 1.0, 0.0, 0.0], 1], [[0.0, 1.0, 0.0, 0.0, 0.0], 2]]

["a5", "a61", "a69"]
[[[0.0, 0.0, "?", "?", 0.0], 1], [[0.0, 0.0, 1.0, 2.0, 0.0], 1], [[1.0, 1.0, 0.0, 1.0, 0.0], 1],
[[ "?", 0.0, 1.0, 2.0, 0.0], 1], [[1.0, "?", 0.0, 0.0, 1.0], 2], [[0.0, 0.0, 0.0, 0.0, 0.0], 4], [[ "?",
0.0, "?", "?", 0.0], 2], [[1.0, 1.0, 1.0, 0.0, 0.0], 1], [[ "?", 1.0, 0.0, 0.0, 0.0], 2], [[1.0, 1.0,
 "?", "?", 0.0], 2], [[1.0, 0.0, 1.0, 1.0, 0.0], 3], [[ "?", 0.0, 0.0, 0.0, 0.0], 2], [[0.0, 1.0, "?",
0.0, 0.0], 1], [[0.0, 1.0, 0.0, 0.0, 0.0], 2]]

```

The results from this test case are fairly similar to the results from Large Test Dataset – Test Case #1, with slight variations due to the addition of another decision attribute. In the same manner as Large Test Dataset – Test Case #1, the results of this test case will be compared to pruned results using the same option set in the next test case.

Large Test Dataset – Test Case #4

- Multiple decision attributes
- Number of attributes considered for coverings limited to 3
- No minimum instance coverage for reported rules
- Redundant rules pruned

Attributes to partition on: ["a0", "a1", "a2", "a3", "a4", "a5", "a6", "a7", "a8", "a9", "a10", "a11", "a12", "a13", "a14", "a15", "a16", "a17", "a18", "a19", "a20", "a21", "a22", "a23", "a24", "a25", "a26", "a27", "a28", "a29", "a30", "a31", "a32", "a33", "a34", "a35", "a36", "a37", "a38", "a39", "a40", "a41", "a42", "a43", "a44", "a45", "a46", "a47", "a48", "a49", "a50", "a51", "a52", "a53", "a54", "a55", "a56", "a57", "a58", "a59", "a60", "a61", "a62", "a63", "a64", "a65", "a66", "a67", "a68", "a69", "a70", "a72", "a73", "a74", "a75", "a76"]

Decision attributes: ["a71"]

Value: [2.0] Occurrences: 2
Value: [1.0] Occurrences: 4
Value: [0.0] Occurrences: 14
Value: ["?"] Occurrences: 5

Decision attributes: ["a77"]

Value: [1.0] Occurrences: 2
Value: [0.0] Occurrences: 23

Decision attributes: ["a71", "a77"]

Value: ["?", 0.0] Occurrences: 5
Value: [2.0, 0.0] Occurrences: 2
Value: [0.0, 1.0] Occurrences: 2
Value: [0.0, 0.0] Occurrences: 12
Value: [1.0, 0.0] Occurrences: 4

Coverings:

["a0", "a2", "a69"]
[[["1.0", "?", 0.0, 0.0, 1.0], 2], [{"", "?", "?", "?", 0.0], 2], [{"?", "", 1.0, 2.0, 0.0], 1], [{"_", 0.0, "?", "?", 0.0], 2], [{"0.0, "_", 1.0, 2.0, 0.0], 1], [{"_", 1.0, 0.0, 1.0, 0.0], 1], [{"1.0, "_", "?", "?", 0.0], 1], [{"1.0, 0.0, "_", 0.0, 0.0], 1], [{"_", 1.0, 1.0, 1.0, 0.0], 3], [{"0.0, "_", 0.0, 0.0, 0.0], 6], [{"0.0, 1.0, "_", 0.0, 0.0], 1], [{"?", "_", 0.0, 0.0, 0.0], 4]]

["a0", "a61", "a69"]
[[["_", "?", "_", 0.0, 1.0], 2], [{"", 0.0, "?", "?", 0.0], 3], [{"0.0, "_", 1.0, 2.0, 0.0], 1], [{"?", "_", 1.0, 2.0, 0.0], 1], [{"?", 1.0, "_", 0.0, 0.0], 2], [{"1.0, 1.0, 0.0, 1.0, 0.0], 1], [{"1.0, "_", "?", "?", 0.0], 2], [{"0.0, "_", 0.0, 0.0, 0.0], 6], [{"0.0, 1.0, "_", 0.0, 0.0], 1], [{"1.0, 0.0, "_", 1.0, 0.0], 3], [{"?", "_", 0.0, 0.0, 0.0], 2]]

["a1", "a61", "a69"]
[[["_", "?", "_", 0.0, 1.0], 2], [{"0.0, 1.0, "_", 0.0, 0.0], 4], [{"_", 0.0, "?", "?", 0.0], 3], [{"0.0, 0.0, 1.0, 2.0, 0.0], 1], [{"?", "_", 1.0, 2.0, 0.0], 1], [{"?", 1.0, "_", 0.0, 0.0], 2], [{"1.0, 1.0, 0.0, 1.0, 0.0], 1], [{"1.0, "_", "?", "?", 0.0], 2], [{"0.0, "_", 0.0, 0.0, 0.0], 4], [{"1.0, 0.0, "_", 1.0, 0.0], 3], [{"?", "_", 0.0, 0.0, 0.0], 2]]

["a1", "a69", "a72"]
[[["_", 1.0, "?", 2.0, 0.0], 1], [{"1.0, "?", "", "?", 0.0], 2], [{"_", "?", "?", "?", 0.0], 3], [{"1.0, 1.0, "_", 1.0, 0.0], 3], [{"1.0, "_", 1.0, 0.0, 1.0], 2], [{"0.0, 0.0, "_", 0.0, 0.0], 6], [{"1.0, "_", 0.0, 1.0, 0.0], 1], [{"?", 1.0, "_", 2.0, 0.0], 1], [{"?", 0.0, "_", 0.0, 0.0], 4], [{"0.0, "_", 0.0, 0.0, 0.0], 1]]

["a2", "a5", "a69"]
[[["?", "_", "?", "?", 0.0], 2], [{"0.0, 1.0, "_", 0.0, 0.0], 1], [{"0.0, "?", "_", "?", 0.0], 1], [{"?", "_", 1.0, 2.0, 0.0], 1], [{"0.0, "_", "?", "?", 0.0], 1], [{"_", 0.0, 1.0, 2.0, 0.0], 1], [{"1.0, "_", 0.0, 1.0, 0.0], 1], [{"_", 1.0, "?", "?", 0.0], 1], [{"1.0, "_", 1.0, 1.0, 0.0], 3], [{"0.0, "_", 0.0, 0.0, 0.0], 6], [{"?", 1.0, 0.0, 0.0, 1.0], 2], [{"1.0, 0.0, "_", 0.0, 0.0], 1], [{"_", "?", 0.0, 0.0, 0.0], 4]]

["a2", "a22", "a69"]
[[["0.0, "_", "?", "?", 0.0], 2], [{"1.0, "_", 0.0, 1.0, 0.0], 1], [{"0.0, 2.0, "_", 0.0, 0.0], 2], [{"_", 9.0, "_", 1.0, 0.0], 1], [{"0.0, 0.0, 1.0, 2.0, 0.0], 1], [{"_", 1.0, "_", 0.0, 0.0], 3], [{"?", 2.0, 0.0, 0.0, 0.0], 2], [{"?", "_", "?", "?", 0.0], 2], [{"0.0, "_", 0.0, 0.0, 0.0], 3], [{"?", 0.0, 0.0, 0.0, 1.0], 2], [{"_", 2.0, "?", "?", 0.0], 1], [{"1.0, 0.0, "?", 0.0, 0.0], 1], [{"?", "?", "_", 0.0, 0.0], 1], [{"1.0, "_", 1.0, 1.0, 0.0], 2], [{"?", "_", 1.0, 2.0, 0.0], 1]]

["a2", "a69", "a72"]


```

[[["_", 1.0, "?", 2.0, 0.0], 1], [{"?", "?", "_", "?", 0.0}, 2], [[1.0, "_", "?", "?", 0.0], 1],
[[0.0, "?", "_", "?", 0.0], 2], [[1.0, 1.0, "_", 1.0, 0.0], 3], [[0.0, 0.0, "_", 0.0, 0.0], 6], [[1.0,
0.0, "_", 1.0, 0.0], 1], [{"?", 1.0, "_", 2.0, 0.0], 1], [{"?", "_", 1.0, 0.0, 1.0], 2], [[0.0, "_",
0.0, 0.0, 0.0], 1], [[1.0, "_", 1.0, 0.0, 0.0], 1], [{"?", 0.0, 0.0, 0.0, 0.0], 4]]

["a3", "a4", "a69"]
[[[0.0, 1.0, "_", 0.0, 0.0], 2], [{"_", "?", "?", "?", 0.0}, 3], [{"?", "_", 1.0, 2.0, 0.0], 1],
[["_", 0.0, "?", "?", 0.0], 1], [{"_", 0.0, 1.0, 2.0, 0.0], 1], [[1.0, "_", 0.0, 1.0, 0.0], 1], [[1.0,
"_", "?", "?", 0.0], 1], [[1.0, "_", 1.0, 1.0, 0.0], 3], [[0.0, "_", 0.0, 0.0, 0.0], 7], [{"?", 1.0,
"_", 0.0, 1.0], 2], [{"_", "?", 0.0, 0.0, 0.0], 3]]

["a3", "a61", "a69"]
[[[0.0, 1.0, "_", 0.0, 0.0], 5], [{"_", 0.0, "?", "?", 0.0}, 3], [[0.0, 0.0, 1.0, 2.0, 0.0], 1],
[["?", "_", 1.0, 2.0, 0.0], 1], [{"?", 1.0, "_", 0.0, 0.0], 1], [[1.0, "_", 0.0, 1.0, 0.0], 1], [[1.0,
"_", "?", "?", 0.0], 2], [[0.0, "_", 0.0, 0.0, 0.0], 4], [[1.0, 0.0, "_", 1.0, 0.0], 3], [{"_", "?",
"_", 0.0, 1.0], 2], [{"_", 0.0, 0.0, 0.0, 0.0], 2]]

["a3", "a69", "a72"]
[[["_", 1.0, "?", 2.0, 0.0], 1], [[1.0, "?", "_", "?", 0.0], 2], [{"_", "?", "?", "?", 0.0], 3],
[[1.0, 1.0, "_", 1.0, 0.0], 3], [[0.0, 0.0, "_", 0.0, 0.0], 7], [[1.0, 0.0, "_", 1.0, 0.0], 1], [{"?",
1.0, "_", 2.0, 0.0], 1], [[0.0, "_", 1.0, 0.0, 0.0], 1], [{"?", "_", 1.0, 0.0, 1.0], 2], [[0.0, "_",
0.0, 0.0, 0.0], 1], [{"?", 0.0, 0.0, 0.0, 0.0], 3]]

["a4", "a22", "a69"]
[[[1.0, 2.0, 0.0, 1.0, 0.0], 1], [[0.0, 2.0, "_", 0.0, 0.0], 1], [[0.0, "_", "?", "?", 0.0], 1],
[["_", 9.0, "_", 1.0, 0.0], 1], [[0.0, "_", 1.0, 2.0, 0.0], 1], [{"_", 1.0, "_", 0.0, 0.0], 3], [[1.0,
0.0, 0.0, 0.0, 1.0], 2], [{"?", "_", 0.0, 0.0, 0.0], 4], [{"?", "_", "?", "?", 0.0], 3], [[0.0, "_",
0.0, 0.0, 0.0], 2], [{"_", 2.0, "?", "?", 0.0], 1], [[1.0, 0.0, "?", 0.0, 0.0], 1], [[1.0, 0.0, 1.0,
1.0, 0.0], 2], [{"?", "_", 1.0, 2.0, 0.0], 1], [[1.0, 2.0, 1.0, 0.0, 0.0], 1]]

["a5", "a22", "a69"]
[[[1.0, 2.0, 0.0, 1.0, 0.0], 1], [[0.0, 2.0, "_", 0.0, 0.0], 1], [{"_", "?", "?", "?", 0.0], 1],
[["_", 9.0, "_", 1.0, 0.0], 1], [[0.0, "_", 1.0, 2.0, 0.0], 1], [{"_", 1.0, "_", 0.0, 0.0], 3], [[1.0,
0.0, 0.0, 0.0, 1.0], 2], [{"?", "_", 0.0, 0.0, 0.0], 3], [[0.0, "_", 0.0, 0.0, 0.0], 3], [[0.0, 0.0,
"?", 0.0, 0.0], 1], [[1.0, "_", "?", "?", 0.0], 2], [[1.0, 0.0, 1.0, 1.0, 0.0], 2], [{"?", "_", 1.0,
2.0, 0.0], 1], [{"?", 0.0, "_", "?", 0.0], 2], [[1.0, 2.0, 1.0, 0.0, 0.0], 1]]

["a5", "a61", "a69"]
[[["_", "?", "_", 0.0, 1.0], 2], [{"_", 0.0, "?", "?", 0.0], 3], [[0.0, "_", 1.0, 2.0, 0.0], 1],
[["?", "_", 1.0, 2.0, 0.0], 1], [{"?", 1.0, "_", 0.0, 0.0], 2], [[1.0, 1.0, 0.0, 1.0, 0.0], 1], [[1.0,
"_", "?", "?", 0.0], 2], [[0.0, "_", 0.0, 0.0, 0.0], 6], [[0.0, 1.0, "_", 0.0, 0.0], 1], [{"_", 1.0,
1.0, 0.0, 0.0], 1], [[1.0, 0.0, "_", 1.0, 0.0], 3], [{"?", "_", 0.0, 0.0, 0.0], 2]]

```

As with Large Test Dataset – Test Case #3 involving a single decision attribute, the results from Large Test Dataset using multiple decision attributes also results in correct pruning. Consider the rules from the following unpruned covering:

```

["a2", "a22", "a69"]
[[[0.0, 2.0, 0.0, 0.0, 0.0], 1], [[0.0, 0.0, 0.0, 0.0, 0.0], 2], [[0.0, "?", 0.0, 0.0, 0.0], 1],
[[0.0, 1.0, 0.0, 0.0, 0.0], 2]]

```

Now, notice that not all of these rules are grouped into the same pruned rule, as evidenced by the coverage value of the following pruned rule:

```

[[0.0, "_", 0.0, 0.0, 0.0], 3]

```

This is because the rules are grouped with pruned rules according to the order in which the original rules are generated. The coverage count shown above for the pruned rule, while not ideal, is still correct, as evidenced by the rule groupings shown below:

```

["a2", "a22", "a69"]
[[[0.0, 0.0, 0.0, 0.0, 0.0], 2], [[0.0, "?", 0.0, 0.0, 0.0], 1] ==> [[0.0, "_", 0.0, 0.0, 0.0], 3]
[[0.0, 2.0, 0.0, 0.0, 0.0], 1], [[0.0, 2.0, 1.0, 0.0, 0.0], 1] ==> [[0.0, 2.0, "_", 0.0, 0.0], 2]
[[0.0, 1.0, 0.0, 0.0, 0.0], 2], [{"?", 1.0, 0.0, 0.0, 0.0], 1] ==> [{"_", 1.0, "_", 0.0, 0.0], 3]

```

Large Test Dataset – Test Case #5

- Single decision attribute
- Number of attributes considered for coverings limited to 3
- Minimum instance coverage for reported rules set to 3
- Redundant rules not pruned

Attributes to partition on: ["a0", "a1", "a2", "a3", "a4", "a5", "a6", "a7", "a8", "a9", "a10", "a11", "a12", "a13", "a14", "a15", "a16", "a17", "a18", "a19", "a20", "a21", "a22", "a23", "a24", "a25", "a26", "a27", "a28", "a29", "a30", "a31", "a32", "a33", "a34", "a35", "a36", "a37", "a38", "a39", "a40", "a41", "a42", "a43", "a44", "a45", "a46", "a47", "a48", "a49", "a50", "a51", "a52", "a53", "a54", "a55", "a56", "a57", "a58", "a59", "a60", "a61", "a62", "a63", "a64", "a65", "a66", "a67", "a68", "a69", "a70", "a72", "a73", "a74", "a75", "a76", "a77"]

Decision attributes: ["a71"]

Value: [2.0]	Occurrences: 2
Value: [1.0]	Occurrences: 4
Value: [0.0]	Occurrences: 14
Value: ["?"]	Occurrences: 5

Coverings:

["a0", "a2", "a69"]
[[["?", "?", 0.0, 0.0], 3], [[1.0, 1.0, 1.0, 1.0], 3], [[0.0, 0.0, 0.0, 0.0], 5]]

["a0", "a61", "a69"]
[[[1.0, 0.0, 1.0, 1.0], 3], [[0.0, 0.0, 0.0, 0.0], 4]]

["a1", "a61", "a69"]
[[[0.0, 0.0, "?", "?"], 3], [[1.0, 0.0, 1.0, 1.0], 3], [[0.0, 0.0, 0.0, 0.0], 4]]

["a1", "a69", "a72"]
[[["?", 0.0, 0.0, 0.0], 3], [[0.0, "?", "?", "?"], 3], [[1.0, 1.0, 0.0, 1.0], 3], [[0.0, 0.0, 0.0, 0.0], 6]]

["a2", "a5", "a69"]
[[["?", "?", 0.0, 0.0], 4], [[1.0, 1.0, 1.0, 1.0], 3], [[0.0, 0.0, 0.0, 0.0], 6]]

["a2", "a8", "a69"]
[[["?", "?", 0.0, 0.0], 3], [[0.0, 0.0, 0.0, 0.0], 6]]

["a2", "a12", "a69"]
[[["?", 0.0, 0.0, 0.0], 3], [[0.0, 0.0, 0.0, 0.0], 4]]

["a2", "a16", "a69"]
[[["?", 0.0, 0.0, 0.0], 4], [[0.0, 0.0, 0.0, 0.0], 4]]

["a2", "a20", "a69"]
[[[0.0, "?", 0.0, 0.0], 3], [["?", 0.0, 0.0, 0.0], 3], [["?", 1.0, 0.0, 0.0], 3]]

["a2", "a21", "a69"]
[[[0.0, 0.0, 0.0, 0.0], 3]]

["a2", "a22", "a69"]
[]

["a2", "a23", "a69"]
[[["?", 0.0, 0.0, 0.0], 4], [[0.0, 0.0, 0.0, 0.0], 4]]

["a2", "a25", "a69"]
[[["?", 0.0, 0.0, 0.0], 4], [[0.0, 0.0, 0.0, 0.0], 4]]

["a2", "a51", "a69"]
[[[1.0, 1.0, 1.0, 1.0], 3], [["?", 2.0, 0.0, 0.0], 4], [[0.0, 1.0, 0.0, 0.0], 4]]

["a2", "a56", "a69"]
[[["?", 0.0, 0.0, 0.0], 3], [[0.0, 0.0, 0.0, 0.0], 5], [["?", 1.0, 0.0, 0.0], 3]]

["a2", "a69", "a72"]
[[["?", 0.0, 0.0, 0.0], 4], [[1.0, 1.0, 0.0, 1.0], 3], [[0.0, 0.0, 0.0, 0.0], 5]]

```

["a3", "a4", "a69"]
[[["?", "?", 0.0, 0.0], 3], [[1.0, 1.0, 1.0, 1.0], 3], [[0.0, 0.0, 0.0, 0.0], 5]]

["a3", "a12", "a69"]
[[[0.0, 0.0, 0.0, 0.0], 5]]

["a3", "a23", "a69"]
[[["?", 0.0, 0.0, 0.0], 3], [[0.0, 0.0, 0.0, 0.0], 5]]

["a3", "a25", "a69"]
[[["?", 0.0, 0.0, 0.0], 3], [[0.0, 0.0, 0.0, 0.0], 5]]

["a3", "a61", "a69"]
[[[0.0, 0.0, "?", "?"], 3], [[1.0, 0.0, 1.0, 1.0], 3], [[0.0, 0.0, 0.0, 0.0], 4], [[0.0, 1.0, 0.0, 0.0], 3]]

["a3", "a69", "a72"]
[[["?", 0.0, 0.0, 0.0], 3], [[0.0, "?", "?", "?"], 3], [[1.0, 1.0, 0.0, 1.0], 3], [[0.0, 0.0, 0.0, 0.0], 6]]

["a4", "a22", "a69"]
[]

["a5", "a22", "a69"]
[]

["a5", "a61", "a69"]
[[[1.0, 0.0, 1.0, 1.0], 3], [[0.0, 0.0, 0.0, 0.0], 4]]

```

In the results for this test case, there are coverings displayed which contain no rules. This is because, while the coverings are still valid and do contain rules, every rule contained within those coverings did not mean the minimum coverage requirement. Hence, only rules that meet the minimum coverage requirements will be displayed, even though all of the valid coverings for the test case will still be displayed by the program.

Large Test Dataset – Test Case #6

- Single decision attribute
- Number of attributes considered for coverings limited to 3
- Minimum instance coverage for reported rules set to 3
- Redundant rules pruned

Attributes to partition on: ["a0", "a1", "a2", "a3", "a4", "a5", "a6", "a7", "a8", "a9", "a10", "a11", "a12", "a13", "a14", "a15", "a16", "a17", "a18", "a19", "a20", "a21", "a22", "a23", "a24", "a25", "a26", "a27", "a28", "a29", "a30", "a31", "a32", "a33", "a34", "a35", "a36", "a37", "a38", "a39", "a40", "a41", "a42", "a43", "a44", "a45", "a46", "a47", "a48", "a49", "a50", "a51", "a52", "a53", "a54", "a55", "a56", "a57", "a58", "a59", "a60", "a61", "a62", "a63", "a64", "a65", "a66", "a67", "a68", "a69", "a70", "a72", "a73", "a74", "a75", "a76", "a77"]

Decision attributes: ["a71"]
Value: [2.0] Occurrences: 2
Value: [1.0] Occurrences: 4
Value: ["?"] Occurrences: 5
Value: [0.0] Occurrences: 14

Coverings:

["a0", "a2", "a69"]
[[["_", "?", 0.0, 0.0], 6], [{"_", 1.0, 1.0, 1.0}, 3], [[0.0, "_", 0.0, 0.0], 5]]

["a0", "a61", "a69"]
[[[0.0, 1.0, "_", 0.0], 3], [[1.0, 0.0, "_", 1.0], 3], [[0.0, "_", 0.0, 0.0], 4]]

["a1", "a61", "a69"]
[[[0.0, 1.0, "_", 0.0], 4], [[1.0, 0.0, "_", 1.0], 3], [[0.0, "_", 0.0, 0.0], 4], [{"_", 0.0, "?", "?"], 3]]

["a1", "a69", "a72"]
[[[1.0, "_", 0.0, 1.0], 4], [{"_", "_", 1.0, 0.0}, 4], [{"_", "?", "?", "?"], 5], [[0.0, 0.0, "_", 0.0], 6], [{"?", 0.0, "_", 0.0], 3]]

["a2", "a5", "a69"]
[[["?", "_", 0.0, 0.0], 6], [[1.0, "_", 1.0, 1.0], 3], [[0.0, "_", 0.0, 0.0], 6]]

["a2", "a8", "a69"]
[[["?", "_", 0.0, 0.0], 6], [[0.0, "_", 0.0, 0.0], 6]]

["a2", "a12", "a69"]
[[["?", "_", 0.0, 0.0], 6], [{"_", 0.0, "?", "?"], 3], [[0.0, "_", 0.0, 0.0], 5]]

["a2", "a16", "a69"]
[[["?", "_", 0.0, 0.0], 6], [[0.0, "_", 0.0, 0.0], 5]]

["a2", "a20", "a69"]
[[[0.0, "?", "_", 0.0], 4], [{"?", "_", 0.0, 0.0], 6]]

["a2", "a21", "a69"]
[[[0.0, "_", 0.0, 0.0], 6], [[1.0, "_", 1.0, 1.0], 3], [{"?", "_", 0.0, 0.0], 6]]

["a2", "a22", "a69"]
[[["?", "_", 0.0, 0.0], 6], [[1.0, "_", 1.0, 1.0], 3], [[0.0, "_", 0.0, 0.0], 5]]

["a2", "a23", "a69"]
[[["?", "_", 0.0, 0.0], 6], [{"_", 0.0, "?", "?"], 3], [[0.0, "_", 0.0, 0.0], 6]]

["a2", "a25", "a69"]
[[["?", "_", 0.0, 0.0], 6], [{"_", 0.0, "?", "?"], 3], [[0.0, "_", 0.0, 0.0], 6]]

["a2", "a51", "a69"]
[[[0.0, "_", 0.0, 0.0], 6], [{"?", "_", 0.0, 0.0], 6], [[1.0, "_", 1.0, 1.0], 3]]

["a2", "a56", "a69"]
[[[1.0, "_", 1.0, 1.0], 3], [{"_", 0.0, "?", "?"], 3], [{"?", "_", 0.0, 0.0], 6], [[0.0, "_", 0.0, 0.0], 6]]

```

["a2", "a69", "a72"]
[[["_", "_", 1.0, 0.0], 4], [[1.0, 1.0, "_", 1.0], 3], [[0.0, 0.0, "_", 0.0], 5], [{"?", 0.0, "_", 0.0}, 4]]

["a3", "a4", "a69"]
[[["?", "_", 0.0, 0.0], 5], [{"_", "?", "?", "?"], 3], [[0.0, "_", 0.0, 0.0], 7], [[1.0, "_", 1.0, 1.0], 3]]

["a3", "a12", "a69"]
[[["?", "_", 0.0, 0.0], 5], [[0.0, "_", 0.0, 0.0], 6]]

["a3", "a23", "a69"]
[[["?", "_", 0.0, 0.0], 5], [[0.0, "_", 0.0, 0.0], 6]]

["a3", "a25", "a69"]
[[["?", "_", 0.0, 0.0], 5], [[0.0, "_", 0.0, 0.0], 6]]

["a3", "a61", "a69"]
[[[0.0, 1.0, "_", 0.0], 5], [[1.0, 0.0, "_", 1.0], 3], [[0.0, "_", 0.0, 0.0], 4], [{"_", 0.0, "?", "?"], 3]]

["a3", "a69", "a72"]
[[["_", "?", "?", "?"], 5], [[1.0, 1.0, "_", 1.0], 3], [{"_", "_", 1.0, 0.0], 4], [[0.0, 0.0, "_", 0.0], 6], [{"?", 0.0, "_", 0.0}, 3]]

["a4", "a22", "a69"]
[[["?", "_", 0.0, 0.0], 5], [{"_", 0.0, 0.0, 0.0], 3], [[0.0, "_", 0.0, 0.0], 3]]

["a5", "a22", "a69"]
[[["?", "_", 0.0, 0.0], 4], [{"_", 0.0, 0.0, 0.0], 4], [[0.0, "_", 0.0, 0.0], 3]]

["a5", "a61", "a69"]
[[[0.0, 1.0, "_", 0.0], 3], [[1.0, 0.0, "_", 1.0], 3], [[0.0, "_", 0.0, 0.0], 4]]

```

Notice that from this test case, there are pruned rules which do not match any of the displayed rules from Large Test Dataset – Test Case #5, meaning that there now exist pruned rules which meet the minimum coverage requirement formed by grouping unpruned rules that did not originally meet the minimum coverage requirement. Consider the following pruned rule:

```

["a0", "a61", "a69"]
[[0.0, 1.0, "_", 0.0], 3]

```

This pruned rule does not match any of the displayed rules for its associated covering in Large Test Dataset – Test Case #5. However, it is made up of a grouping of unpruned rules which did not meet the minimum coverage requirement, as evidenced by the results of Large Test Dataset – Test Case #1:

```

["a0", "a61", "a69"]
[[0.0, 1.0, "?", 0.0], 1], [[0.0, 1.0, 0.0, 0.0], 2]] ==> [[0.0, 1.0, "_", 0.0], 3]

```

Appendix

(NOTE: The contents of the relation appear differently when printed by the program because the Rarff library automatically converts the numeric attribute values to floating-point precision values.)

Small Test Dataset (table3_10_fg.arff)

```
@relation table3_10_fg
```

```
@attribute a numeric
```

```
@attribute b {L,R,S}
```

```
@attribute c numeric
```

```
@attribute d {L,H}
```

```
@attribute f numeric
```

```
@attribute g {L,H}
```

```
@data
```

```
0,L,0,L,0,L
```

```
0,R,1,L,1,L
```

```
0,L,0,L,0,L
```

```
0,R,1,L,1,L
```

```
1,R,0,L,2,H
```

```
1,R,0,L,2,H
```

```
2,S,2,H,3,H
```

```
2,S,2,H,3,H
```

Large Test Dataset (*wilkinsonMatrix.arff*)

(NOTE: The attributes in the set {a22, a23, a24, a25, a69, a70, a71, a72} are treated as string attributes by the Rarff library, even though they are explicitly declared as numeric in the wilkinsonMatrix.arff file, because the first value given for those attributes in the dataset is the missing value symbol ('?'). Since the RICO algorithm treats all values as nominal by default, this has no impact on the functionality of the program or the accuracy of its results.)

```
@relation wilkinsonmatrix
```

```
@attribute a0 numeric
@attribute a1 numeric
@attribute a2 numeric
@attribute a3 numeric
@attribute a4 numeric
@attribute a5 numeric
@attribute a6 numeric
@attribute a7 numeric
@attribute a8 numeric
@attribute a9 numeric
@attribute a10 numeric
@attribute a11 numeric
@attribute a12 numeric
@attribute a13 numeric
@attribute a14 numeric
@attribute a15 numeric
@attribute a16 numeric
@attribute a17 numeric
@attribute a18 numeric
@attribute a19 numeric
@attribute a20 numeric
@attribute a21 numeric
@attribute a22 numeric
@attribute a23 numeric
@attribute a24 numeric
@attribute a25 numeric
@attribute a26 numeric
@attribute a27 numeric
@attribute a28 numeric
@attribute a29 numeric
@attribute a30 numeric
@attribute a31 numeric
@attribute a32 numeric
@attribute a33 numeric
@attribute a34 numeric
@attribute a35 numeric
@attribute a36 numeric
@attribute a37 numeric
@attribute a38 numeric
@attribute a39 numeric
@attribute a40 numeric
@attribute a41 numeric
@attribute a42 numeric
@attribute a43 numeric
@attribute a44 numeric
@attribute a45 numeric
@attribute a46 numeric
@attribute a47 numeric
@attribute a48 numeric
@attribute a49 numeric
@attribute a50 numeric
@attribute a51 numeric
@attribute a52 numeric
@attribute a53 numeric
@attribute a54 numeric
@attribute a55 numeric
@attribute a56 numeric
@attribute a57 numeric
```

@attribute	a58	numeric
@attribute	a59	numeric
@attribute	a60	numeric
@attribute	a61	numeric
@attribute	a62	numeric
@attribute	a63	numeric
@attribute	a64	numeric
@attribute	a65	numeric
@attribute	a66	numeric
@attribute	a67	numeric
@attribute	a68	numeric
@attribute	a69	numeric
@attribute	a70	numeric
@attribute	a71	numeric
@attribute	a72	numeric
@attribute	a73	numeric
@attribute	a74	numeric
@attribute	a75	numeric
@attribute	a76	numeric
@attribute	a77	numeric

```
@data
```

[illegible]