More Effective and More Maintainable

Test Suites, with

Combinatorial Testing

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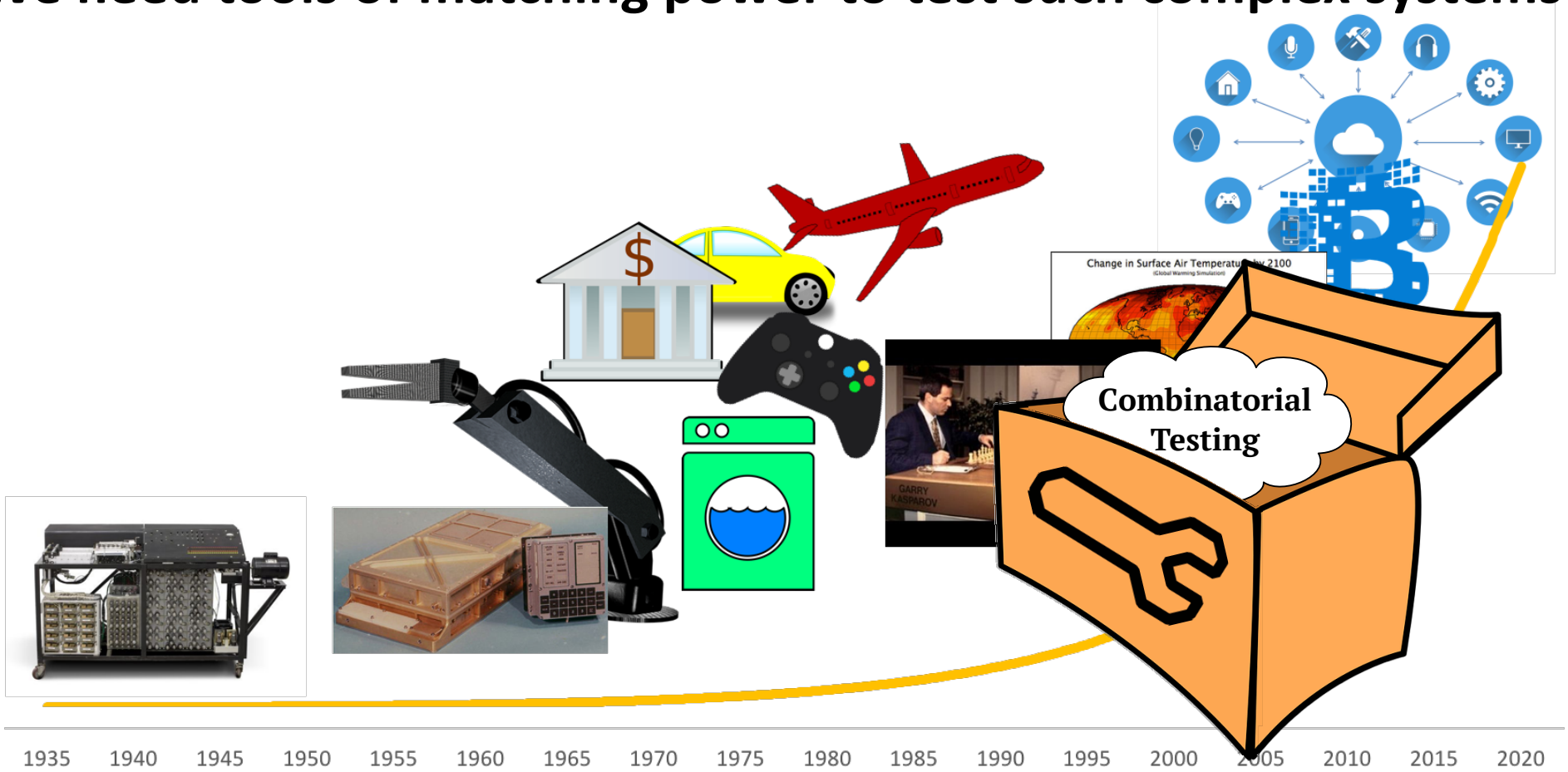
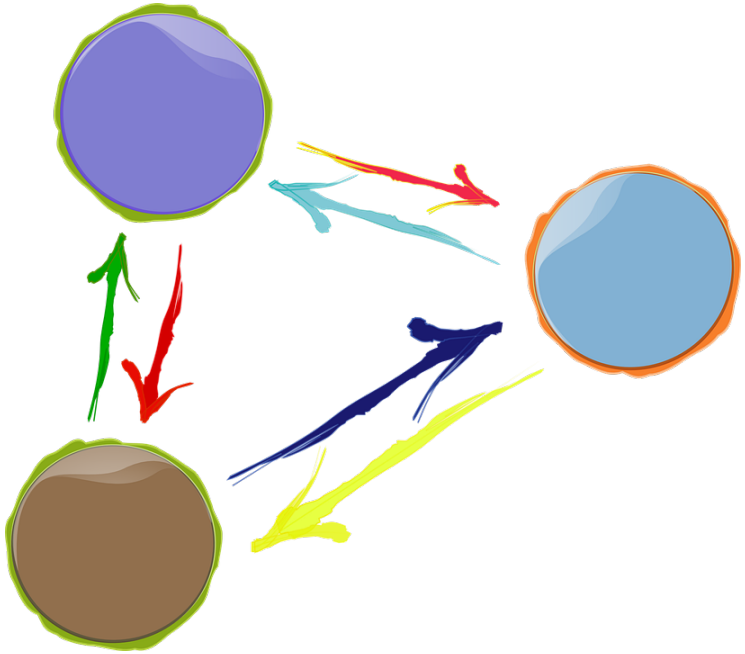
The Norwegian
Tax Administration

1935 1940 1945 1950 1955 1960 1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020

We need tools of matching power to test such complex systems



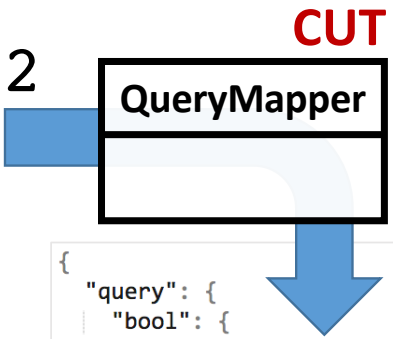
Combinatorial testing focuses on detecting *interaction failures*

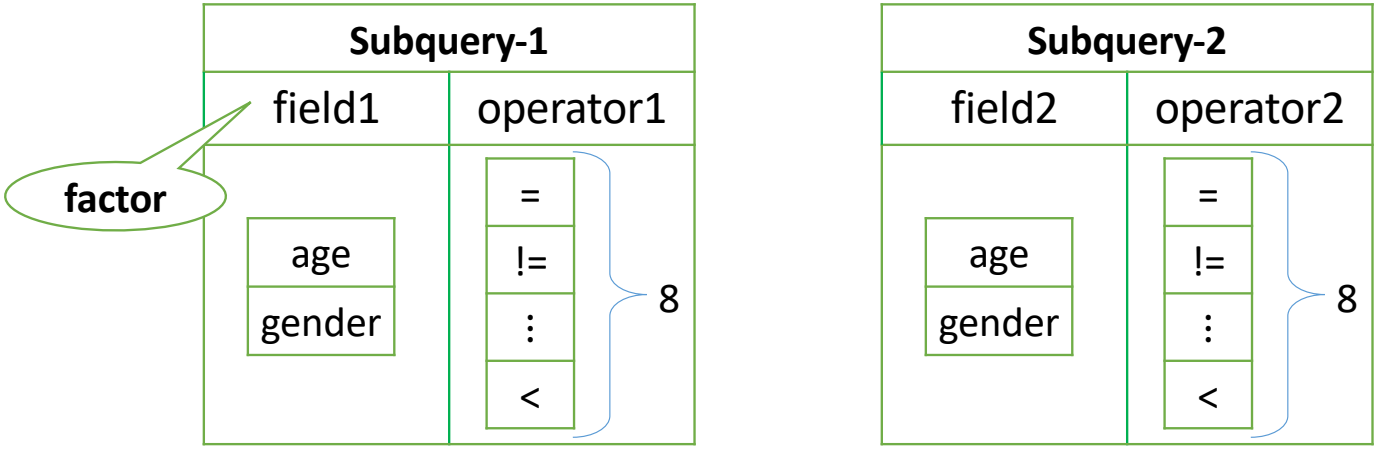


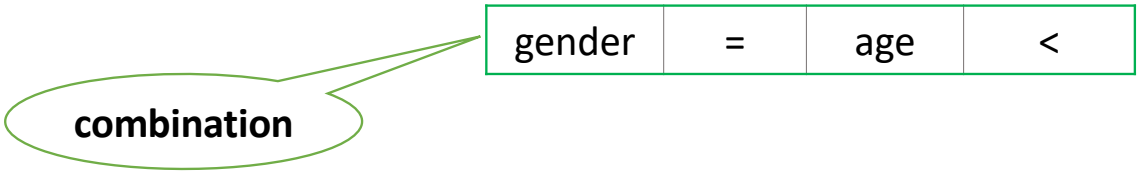
Combinatorial testing focuses on detecting *interaction failures*

/search?feild1=val1&field2<val2

/search?gender=female&age<18







256 combinations!

```
{
  "query": {
    "bool": {
      "must": [
        {
          "term": {
            "field1": "value1"
          }
        },
        {
          "range": {
            "field2": {
              "lte": "value2"
            }
          }
        }
      ],
      "minimum_should_match": 1,
      "boost": 1
    }
  }
}
```

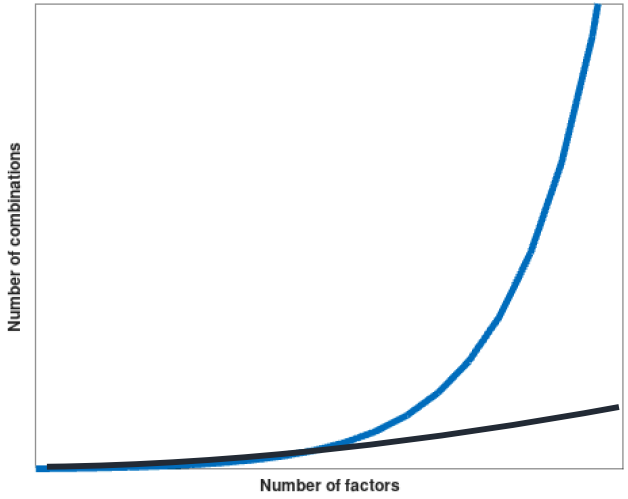
Found two new bugs…

age	exists	age	=

Domain coverage vs. code coverage

Exponential growth problem

Model	# Bugs found	# Combinations	Test exec. time	Test Suite exec. time
2×2×8×8	2	**256**	**50 + 445 ms**	**3.6 s**



t-way combinatorial testing gives a practical way to detect interaction failures

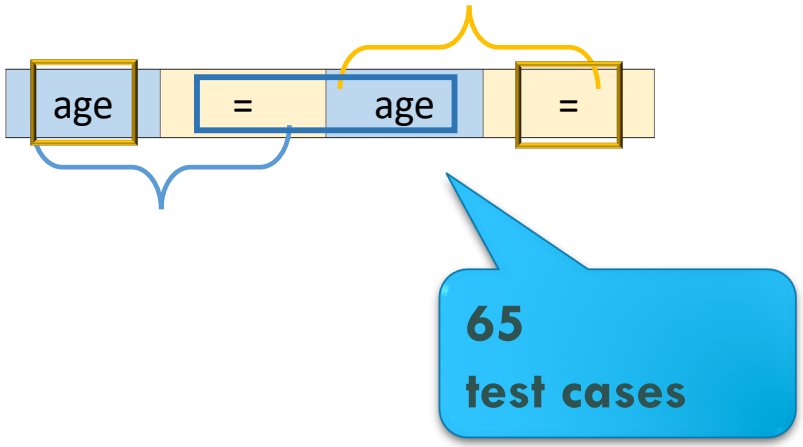
	field1	op.1	field2	op.2
1	age	=	age	=
2	age	=	age	!=
…				
256	gender	<	gender	<

- All 2-way interactions:
  - field1, op.1: 2×8
  - field1, field2: 2×2
  - field1, op.2: 2×8
  - op.1, field2 : 8×2
  - op.1, op.2: 8×8
  - field2, op.2: 2×8

132 pairs to cover!

t-way combinatorial testing gives a practical way to detect interaction failures

	field1	op.1	field2	op.2
1	age	=	age	=
2	age	=	age	!=
...				
256	gender	<	gender	<



- All 2-way interactions:
  - field1, op.1: 2×8
  - field1, field2: 2×2
  - field1, op.2: 2×8
  - op.1, field2 : 8×2
  - op.1, op.2: 8×8
  - field2, op.2: 2×8

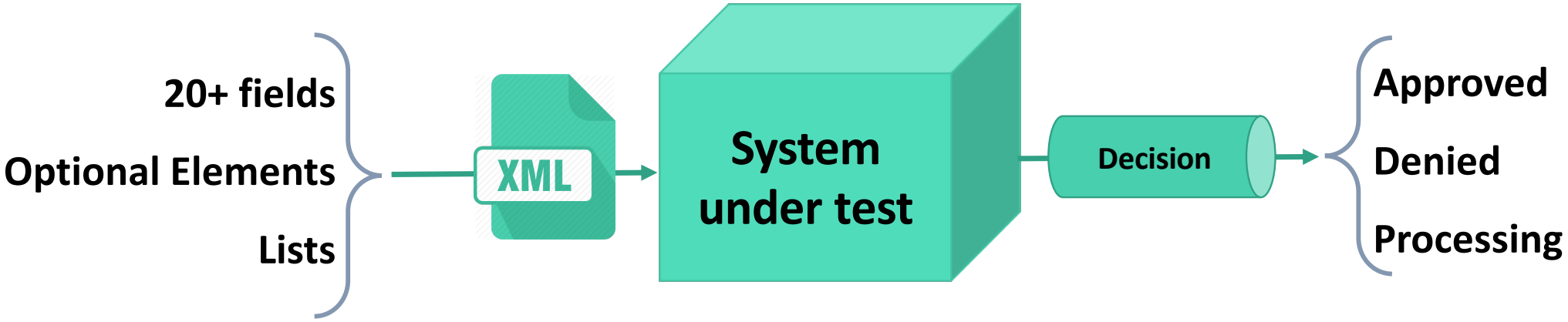
132 pairs to cover!

An NP-Hard problem

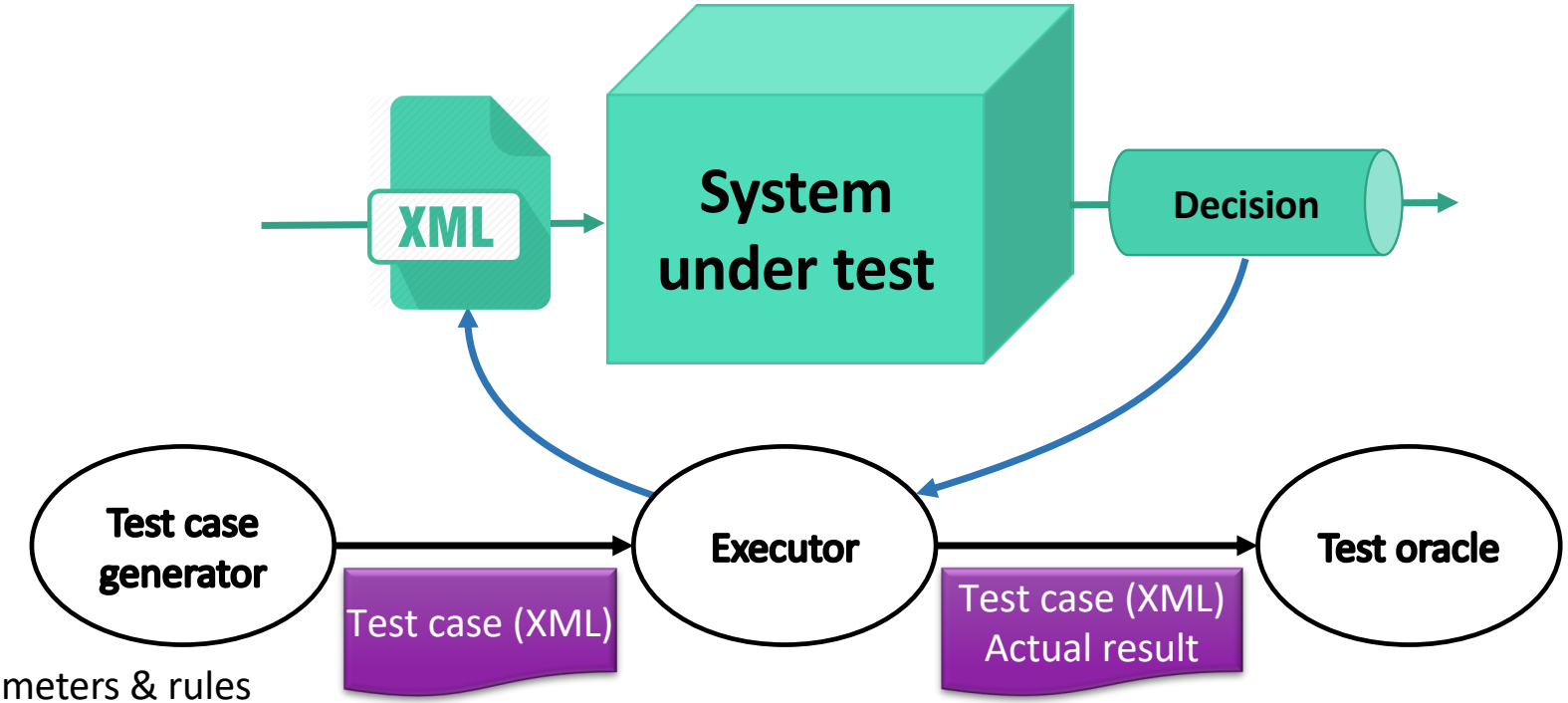
Suitable for testing larger systems

Use a top-down approach

End-to-end testing with combinatorial test case generator



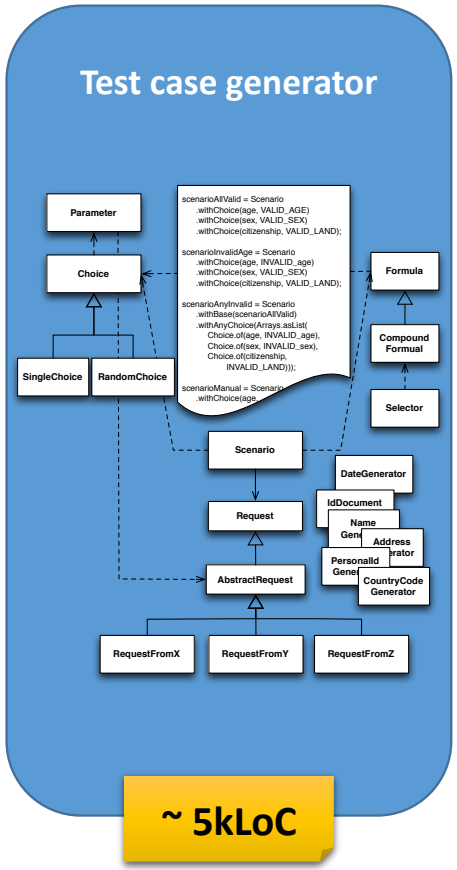
End-to-end testing with combinatorial test case generator



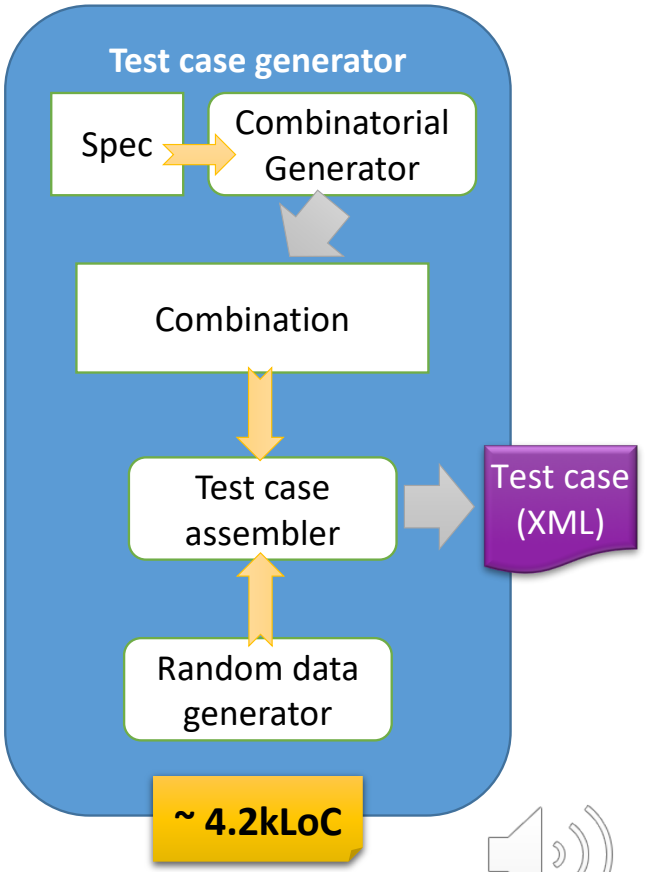
Complexity:

- Many parameters & rules
- Changing rules
- Cope with the dynamics of the environment
- Uniqueness constraints

End-to-end testing with a combinatorial test case generator



Combinatorial testing



Was the use of combinatorial testing effective?

A particularly interesting bug

Tuning the test case generator

- Model
  - 11 parameters (factors)
  - Each 2-5 equivalence classes
  - 6 constraints

- Interaction strength
  - 3-way interactions

Approval	13
Denial	193
Processing	19
Total	**225**

Use mixed-strength interactions for a better scenario distribution

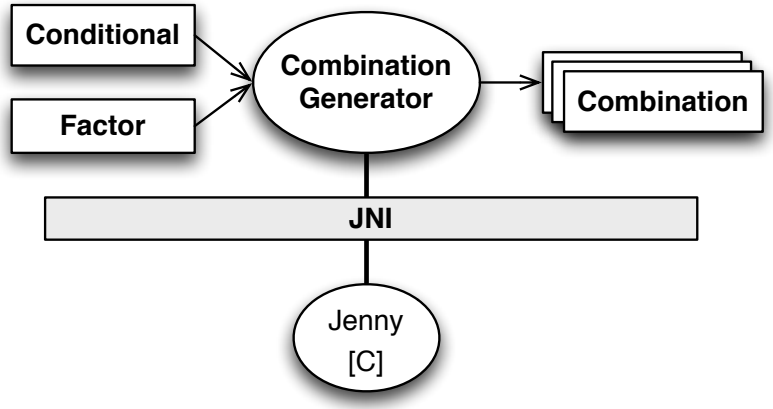
- Model
  - 11 parameters (factors)
  - Each 2-5 equivalence classes
  - 6 constraints
- Interaction strength
  - 3-way interactions

Approval	13
Denial	193
Processing	19
Total	**225**

- Added more test cases covering 4-way or 5-way interactions

Approval	76
Denial	1126
Processing	87
Total	**1289**

Approval	76
Denial	193
Processing	87
Total	**356**



http://burtleburtle.net/bob/math/jenny.html

```
<dependency>
  <groupId>io.github.rbehjati</groupId>
  <artifactId>genie</artifactId>
  <version>0.1.0</version>
</dependency>
```

https://github.com/rbehjati/genie

Thanks!