Scenario Analysis: Generation of Possible Scenario Interpretations and their Visualization

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What does a scenario mean?

- The driver switches on the car
- The instrument cluster is turned on and stays active
- After the trip the driver switches off the ignition
- The instrument cluster stays active for 30 seconds and then turns itself off
- The driver leaves the car
What does a scenario mean?

- The driver switches on the car
- The instrument cluster is turned on and stays active
- After the trip the driver switches off the ignition
- The instrument cluster stays active for 30 seconds and then turns itself off
- The driver leaves the car

Every time when...

... the system reacts
What does a scenario mean?

- The driver switches on the car
- The instrument cluster is turned on and stays active
- After the trip the driver switches off the ignition
- The instrument cluster stays active for 30 seconds and then turns itself off
- The driver leaves the car

First independent interaction...

... and second independent interaction
What does a scenario mean?

- The driver switches on the car
- The instrument cluster is turned on and stays active
- After the trip the driver switches off the ignition
- The instrument cluster stays active for 30 seconds and then turns itself off
- The driver leaves the car

If... then...

1\textsuperscript{st} interaction...

... 2\textsuperscript{nd} interaction
Overview

- Motivation: ambiguous scenarios
- **Specification patterns**
- Application of patterns: brute force
- Intelligent application
- Summary
Specification patterns

Patterns

<table>
<thead>
<tr>
<th>Pattern</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Response</td>
<td>38</td>
</tr>
<tr>
<td>Universality</td>
<td>13</td>
</tr>
<tr>
<td>Absence</td>
<td>12</td>
</tr>
<tr>
<td>UNKNOWN</td>
<td>10</td>
</tr>
<tr>
<td>Precedence</td>
<td>8</td>
</tr>
<tr>
<td>Existence</td>
<td>6</td>
</tr>
<tr>
<td>Resp. Chain</td>
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<tr>
<td>Prec. Chain</td>
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<tr>
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Scopes

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<tr>
<td>Between</td>
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<td>After</td>
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<td>Until</td>
<td>3</td>
</tr>
<tr>
<td>Before</td>
<td>3</td>
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Patterns

<table>
<thead>
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<tbody>
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<td>Universality</td>
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<tr>
<td>Absence</td>
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<td>Existence</td>
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<td>Resp. Chain</td>
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<td>Prec. Chain</td>
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Scopes

<table>
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<td>Between</td>
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<td>After</td>
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<td>Until</td>
<td>6</td>
</tr>
<tr>
<td>Before</td>
<td>1</td>
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</table>
Most frequently used patterns

- **(Non-)Occurrence:**
  - Prohibited events never happen
  - Invariants
  - Desired event occurs eventually

- **Sequence:**
  - Precedence: $B$ is allowed only after $A$
  - Response: If $A$, then $B$
Response: If A, then B

- Is the sequence \((A+)B\) allowed?
- Is the sequence \(AB^+\) allowed?
- Events in between: Is the sequence \(AxB\) allowed?
- Is the sequence \(BAB\) allowed?
- Is \(B\) without \(A\) allowed?
- Does a second \(A\) require a second \(B\)?

Overview

- Motivation: ambiguous scenarios
- Specification patterns
- **Application of patterns: brute force**
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- Summary
MSC: cutting in pieces

 MSC Activation of the instrument cluster

<table>
<thead>
<tr>
<th>prefix</th>
<th>action</th>
<th>response</th>
<th>suffix</th>
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</thead>
<tbody>
<tr>
<td>driver</td>
<td>switches on</td>
<td>switches off ignition</td>
<td>leaves</td>
</tr>
<tr>
<td>car</td>
<td>turns on</td>
<td>stays active for 30 seconds</td>
<td>turns itself off</td>
</tr>
<tr>
<td>ins. clust.</td>
<td>stays active</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total: $O(n^3)$ possibilities to cut
Cutting of structured MSCs

**msc** Cuts and levels

1. **Level 1**
   - a
   - b
   - d

2. **Level 2**
   - c
   - e
   - f1
   - f2
   - f3
   - g
   - h

3. **Level 3**
Structured MSCs: statistics

still $O(n^3)$, but smaller $n$
Overview

- Motivation: ambiguous scenarios
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- Summary
Intelligent application, basics

- **Separately** visualize possible prefix-, suffix- and middle-cuts
- Ask the user which cuts are correct
- Given feedback on cuts, generate and visualize MSCs with:
  - One action, two responses
  - Two actions with a single response
  - Action, event in between, response
  - Response without action
  - Action without response
  - Reactions on second action
Prefix/Suffix visualization

- Cut going down (for prefix) or up (for suffix)
- Yes/no question: „cut correct“?
- Linear complexity $O(n)$

**msc Activation of the instrument cluster**

- driver
- car
- ins. cl.

- switch on
- ins. cl. is turned on
- prefix, end?
- ins. cl. is turned on
- switch off ignition
- ?
- ins. cl. stays active 30s.
- turns itself off
- leave
New MSCs: generation + visualization

When cuts determined, generate/visualize MSCs with:

- One action, two responses
- Two actions with a single response
- ...
Intelligent application, statistics

<table>
<thead>
<tr>
<th></th>
<th>Whole MSCs</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Total</th>
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</thead>
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<tr>
<td>“prefix end” questions</td>
<td>43</td>
<td>29</td>
<td>24</td>
<td>9</td>
<td>105</td>
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<tr>
<td>“suffix begin” questions</td>
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<td>27</td>
<td>28</td>
<td>12</td>
<td>120</td>
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<td>“action/response”-cut questions</td>
<td>28</td>
<td>25</td>
<td>26</td>
<td>9</td>
<td>88</td>
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<td>additional MSCs as required by PROPEL</td>
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<td>175</td>
<td>168</td>
<td>63</td>
<td>602</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>320</strong></td>
<td><strong>256</strong></td>
<td><strong>246</strong></td>
<td><strong>93</strong></td>
<td><strong>915</strong></td>
</tr>
</tbody>
</table>

- 41 MSC
- Yes/no questions
- 10 sec. per question => approx. 3 hours
Overview

- Motivation: ambiguous scenarios
- Specification patterns
- Application of patterns: brute force
- Intelligent application
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Summary

- Cuts ensure that scenarios are subdivided in proper pieces
- Linear complexity
- Generation and visualization of new MSCs: allow to interpret scenarios in the intended way