4. Test Generation from Finite State Models III

Model-Based Testing

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The $\mathscr{W}$-Method

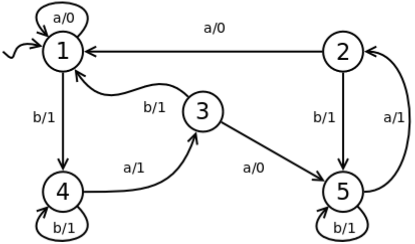
Given an FSM $\mathscr{M} = < \mathscr{X}, \mathscr{Y}, \mathscr{Q}, q_0, \delta, \mathscr{O} >$ the $\mathscr{W}$-method consists of the following steps:

1. Estimate the maximum number of states in the correct design
2. Construct the characterization set $\mathscr{W}$ for the given machine $\mathscr{M}$
3. Construct the testing tree for $\mathscr{M}$ and determine the transition cover set $\mathscr{P}$
4. Construct set $\mathscr{Z}$
5. $\mathscr{P} \cdot \mathscr{Z}$ is the desired test set

$\mathscr{W}$-method fault detection rationale

- A test case generated by the $\mathscr{W} - \textit{method}$ is of the form $r \cdot s$ where $r \in \mathscr{P}$ and $s \in \mathscr{W}$
  - Why can we detect operation errors?
  - Why can we detect transfer errors?

$$\mathscr{P} = \{\epsilon, a, b, bb, ba, bab, baa, baab, baaa, baaab, baaaa\}$$
$$\mathscr{W} = \{a, aa, aaa, baaa\}$$



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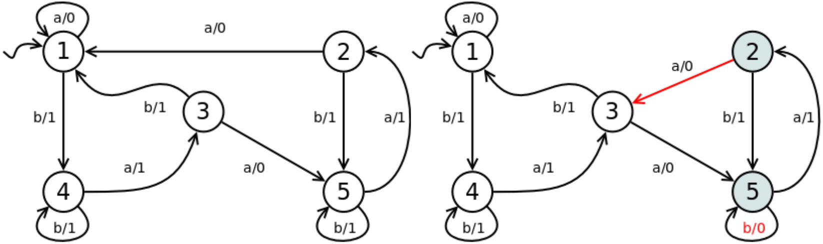

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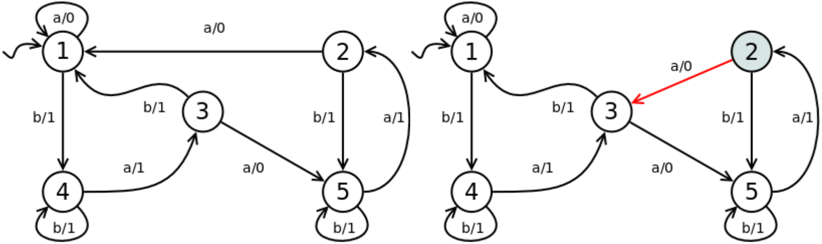


The partial $\mathscr{W}$ – *method* (aka *Wp* – *method*)

Wp – *method* main characteristics:

- is inspired by the $\mathscr{W}$ – *method* it generates smaller test sets
- uses a derivation phase split in two phases that make use of state identification sets $\mathscr{W}_i$ instead of characterization set $\mathscr{W}$
- uses the state cover set ($\mathscr{S}$) to derive the test set.
  - The state cover set is a nonempty set of sequences where each sequence belongs to $\mathscr{X}^*$ and $\forall q_i \in \mathscr{Q} \exists r \in \mathscr{S} \, s.t. \delta(q_0, r) = q_i$
  - from the definition it is evident that $\mathscr{S} \subseteq \mathscr{P}$

The $\mathscr{W}p$ procedure (assuming $m = n$)

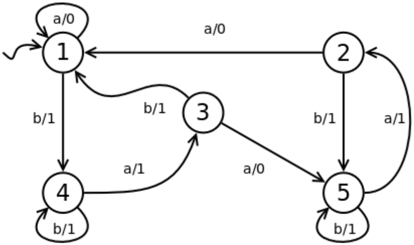
The test set derived using the $\mathscr{W}p - method$ is given by the union to two test sets $\mathscr{T}_1$, $\mathscr{T}_2$ calculated according to the following procedure:

1. Compute sets $\mathscr{P}$, $\mathscr{S}$, $\mathscr{W}$, and $\mathscr{W}_i$
2. $\mathscr{T}_1 = \mathscr{S} \cdot \mathscr{W}$
3. Let $\mathcal{W} = \{\mathscr{W}_1, \mathscr{W}_2, \ldots, \mathscr{W}_n\}$
4. Let $\mathcal{R} = \{r_1, r_2, \ldots, r_k\}$ where $\mathcal{R} = \mathscr{P} - \mathscr{S}$ and $r_j \in \mathcal{R}$ is s.t. $\delta(q_0, r_j) = q_{ij}$
5. $\mathscr{T}_2 = \mathcal{R} \otimes \mathcal{W} = \cup_{j=1}^{K}(\{r_j\} \cdot \mathscr{W}_{ij})$ where $\mathscr{W}_{ij} \in \mathcal{W}$ is the state identification set for state q_{ij}

$\mathscr{W}p$ – *method* rationale

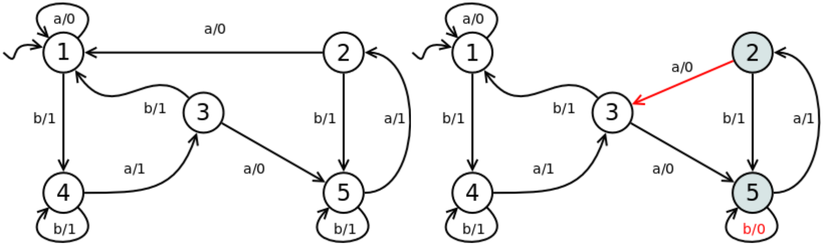
- Phase 1: test are of the form *uv* where $u \in \mathscr{S}$ and $v \in \mathscr{W}$. Reach each state than check if it is distinguishable from another one
- Phase 2: test covers all the missing transitions and then check if the reached state is different from the one specified in the model

$\mathscr{W}p - method$ in practice



$\mathscr{W} = \{a, aa, aaa, baaa\}$
$\mathscr{P} = \{\epsilon, a, b, bb, ba, bab, baa, baab, baaa, baaab, baaaa\}$
$\mathscr{S} = \{\epsilon, b, ba, baa, baaa\}$
$\mathscr{W}_1 = \{baaa, aa, a\}$, $\mathscr{W}_2 = \{baaa, aa, a\}$, $\mathscr{W}_3 = \{aa, a\}$
$\mathscr{W}_4 = \{aaa, a\}$, $\mathscr{W}_5 = \{aaa, a\}$

$\mathscr{W}p - method$ in practice



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$\mathscr{S} = \{\epsilon, b, ba, baa, baaa\}$

$\mathscr{W}_1 = \{baaa, aa, a\}, \mathscr{W}_2 = \{baaa, aa, a\}, \mathscr{W}_3 = \{aa, a\}$

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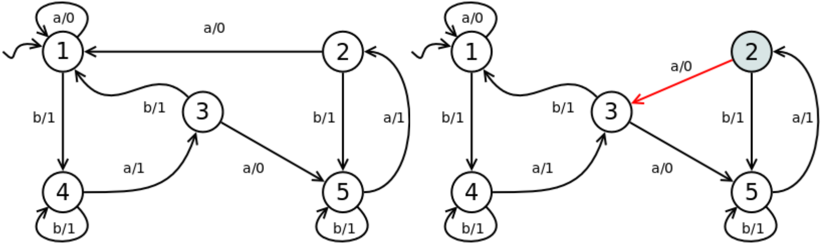
$\mathscr{W}p-method$ in practice



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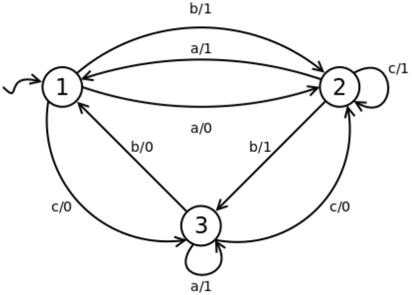
Is it phase 2 needed?

Let's consider the following FSM:



Now introduce an operation error or a transfer error on a "*c*" transition

The $\mathscr{W}p$ procedure (assuming $m > n$)

Modify the derivation of the two sets as follows:

- $\mathscr{T}_1 = \mathscr{S} \cdot \mathscr{Z}$ where $\mathscr{Z} = \mathscr{X}[m-n] \cdot \mathscr{W}$
- $\mathscr{T}_2 = \mathcal{R} \cdot \mathscr{X}[m-n] \otimes \mathcal{W} = \cup_{j=1}^{K}(\{r_{ij}\} \cdot \cup_{u \in \mathscr{X}[m-n]} u \cdot \mathscr{W}_l)$

Applying

Assessment of automata theoretic strategies

Control Flow based techniques are typically assessed according to different criteria:

- State coverage
- Transition coverage
- Switch coverage (n-switch coverage)
- Boundary-interior coverage