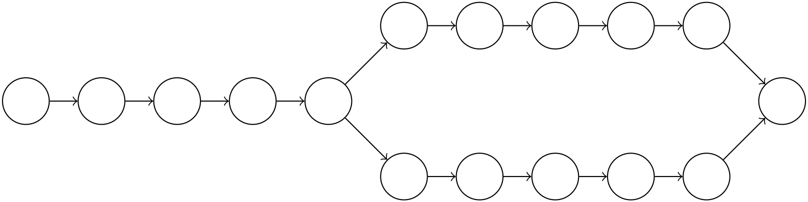
Mini Models

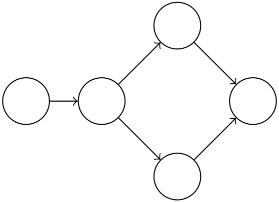
EECS 4315

www.cse.yorku.ca/course/4315/

Model



Mini Model



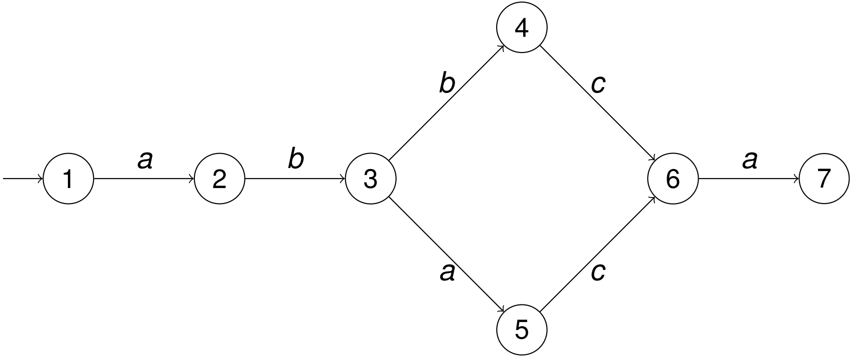
Model

Definition

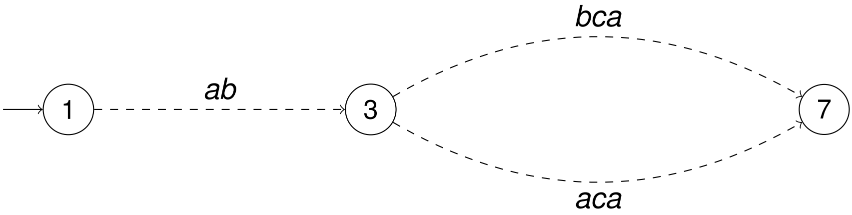
A labelled transition system is a tuple $\langle S, A, \rightarrow, s\rangle$ consisting of

- a set S of states,
- a set A of actions,
- a transition relation $\rightarrow \subseteq S \times A \times S$, and
- a start state $s \in S$.

Model



Mini Model



From Model to Mini Model: Actions

Question

If the actions of the model are elements of the set A, then the actions of the mini model are elements of the set ...

From Model to Mini Model: Actions

Question

If the actions of the model are elements of the set A, then the actions of the mini model are elements of the set ...

Answer

A^+: the set of nonempty finite sequences over A.

From Model to Mini Model: Actions

Question

If the actions of the model are elements of the set A, then the actions of the mini model are elements of the set …

Answer

A^+: the set of nonempty finite sequences over A.

ab, *bca* and *aca* are nonempty finite sequences over $\{a, b, c\}$.

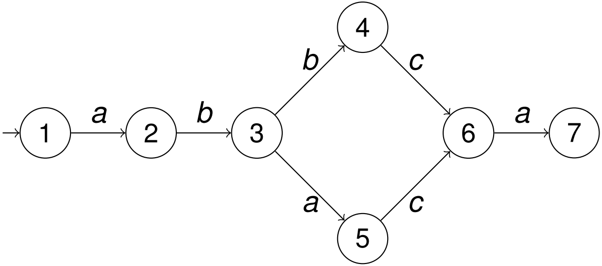
Labelled Transition Systems: successors

Definition

The set $succ(s)$ of successors of the state s is defined by

$$succ(s) = \{\, t \in S \mid \exists a \in A : s \xrightarrow{a} t \,\}.$$

Labelled Transition Systems: successors



$$
\begin{aligned}
succ(1) &= \{2\} \\
succ(2) &= \{3\} \\
succ(3) &= \{4, 5\} \\
succ(4) &= \{6\} \\
succ(5) &= \{6\} \\
succ(6) &= \{7\} \\
succ(7) &= \emptyset
\end{aligned}
$$

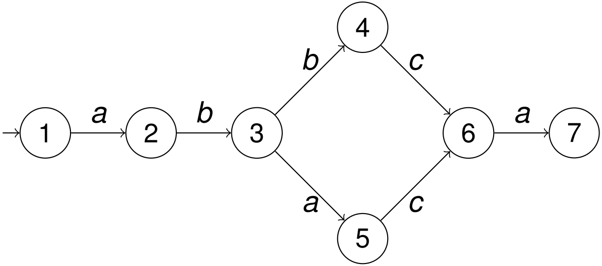
Labelled Transition Systems: predecessors

Definition

The set *pred*(s) of predecessors of the state s is defined by

$$pred(s) = \{ \, t \in S \mid \exists a \in A : t \xrightarrow{a} s \, \}.$$

Labelled Transition Systems: predecessors



$$
\begin{aligned}
pred(1) &= \emptyset \\
pred(2) &= \{1\} \\
pred(3) &= \{2\} \\
pred(4) &= \{3\} \\
pred(5) &= \{3\} \\
pred(6) &= \{4, 5\} \\
pred(7) &= \{6\}
\end{aligned}
$$

From Model to Mini Model: Transitions

Definition

The relation $\dashrightarrow \subseteq S \times A^+ \times S$ is the smallest relation such that

- if there exists a sequence of transitions $s_0 \xrightarrow{a_1} s_1 \xrightarrow{a_2} \cdots \xrightarrow{a_n} s_n$ such that $s_1, \ldots, s_{n-1}$ each have one successor and s_0 and s_n do not, then $s_0 \overset{a_1 \cdots a_n}{\dashrightarrow} s_n$;
- if there exists a sequence of transitions $s_0 \xrightarrow{a_1} s_1 \xrightarrow{a_2} \cdots \xrightarrow{a_n} s_n$ such that $s_1, \ldots, s_{n-1}$ each have one successor and s_n does not and s_0 is the initial state, then $s_0 \overset{a_1 \cdots a_n}{\dashrightarrow} s_n$;

From Model to Mini Model: Transitions

Definition (continued)

- if there exists a sequence of transitions $s_0 \xrightarrow{a_1} s_1 \xrightarrow{a_2} \cdots \xrightarrow{a_m} s_m \xrightarrow{a_{m+1}} \cdots \xrightarrow{a_n} s_n$ such that $s_1, \ldots, s_n$ each have one successor and s_0 does not and $s_1, \ldots s_{n-1}$ are all different and $s_m = s_n$, then $s_0 \overset{a_1 \cdots a_m}{- - \rightarrow} s_m$ and $s_m \overset{a_{m+1} \cdots a_n}{- - - \rightarrow} s_m$;
- if there exists a sequence of transitions $s_0 \xrightarrow{a_1} s_1 \xrightarrow{a_2} \cdots \xrightarrow{a_m} s_m \xrightarrow{a_{m+1}} \cdots \xrightarrow{a_n} s_n$ such that $s_1, \ldots, s_n$ each have one successor and s_0 is the initial state and $s_1, \ldots s_{n-1}$ are all different and $s_m = s_n$, then $s_0 \overset{a_1 \cdots a_m}{- - \rightarrow} s_m$ and $s_m \overset{a_{m+1} \cdots a_n}{- - - \rightarrow} s_m$.

From Model to Mini Model: States

Question

The set S_+ of states of the mini model is ...

From Model to Mini Model: States

Question

The set S_+ of states of the mini model is ...

Answer

the smallest set S_+ such that

- initial state $s \in S_+$ and
- if $s \in S_+$ and $s \xrightarrow{a_1 \ldots a_n} t$ then $t \in S_+$.

From Model to Mini Model: States

Question

The set S_+ of states of the mini model is ...

Answer

the smallest set S_+ such that

- initial state $s \in S_+$ and
- if $s \in S_+$ and $s \xrightarrow{a_1 \ldots a_n} t$ then $t \in S_+$.

Question

Does such a smallest set exist?

From Model to Mini Model: States

Question

The set S_+ of states of the mini model is ...

Answer

the smallest set S_+ such that

- initial state $s \in S_+$ and
- if $s \in S_+$ and $s \xrightarrow{a_1 \ldots a_n} t$ then $t \in S_+$.

Question

Does such a smallest set exist?

Question

Yes. We will discuss the details later in the course.

The set S_+ of states of the mini model can be computed as follows.

$S_+ = \emptyset$
do
  $T = S_+$
  for each $s \in T$
    for each $t \in S$
      if $s \xrightarrow{a_1 \ldots a_n} t$ **for some** $a_1 \ldots a_n \in A$
        $S_+ = S_+ \cup \{t\}$
while $S_+ \neq T$

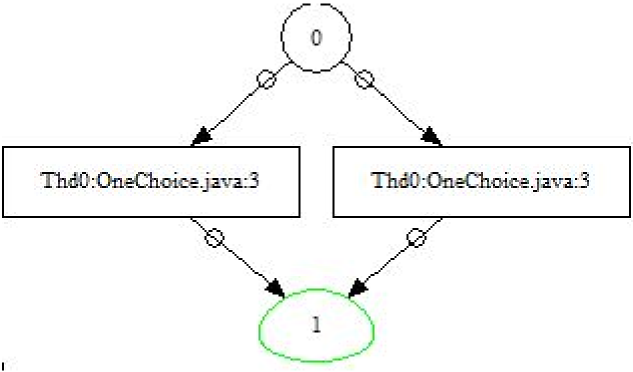
One Choice

```
Random random = new Random();
if (random.nextBoolean())
  System.out.println("1");
else
  System.out.println("2");
System.out.println("done");
```

One Choice

```
target=OneChoice
classpath=.
cg.enumerate_random=true
listener=gov.nasa.jpf.listener.StateSpaceDot
```

One Choice



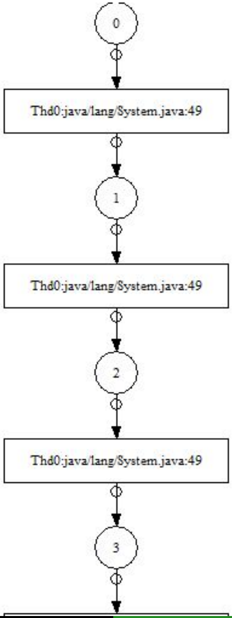
`jpf -show OneChoice1.jpf` produced the following output.

```
----------- Config contents
branch_start = 1
cg.boolean.false_first = true
cg.break_single_choice = false
cg.enable_atomic = true
cg.enumerate_random = true
...
vm.max_transition_length = 50000
...
```

One Choice

```
target=OneChoice
classpath=.
cg.enumerate_random=true
vm.max_transition_length=1
listener=gov.nasa.jpf.listener.StateSpaceDot
```

One Choice

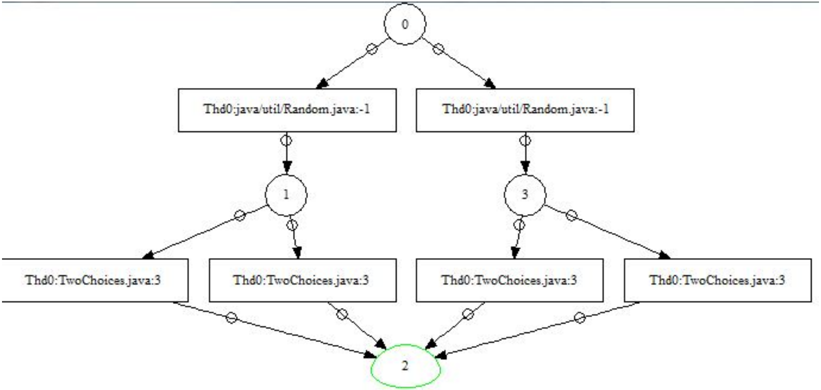


0
Thd0:java/lang/System.java:49
1
Thd0:java/lang/System.java:49
2
Thd0:java/lang/System.java:49
3

Two Choices

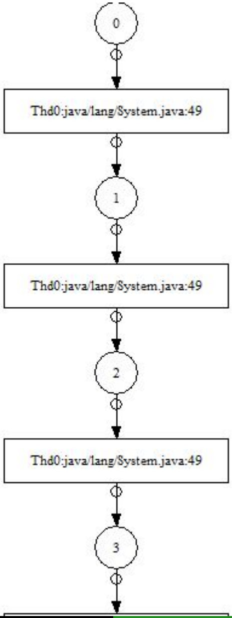
```
Random random = new Random();
if (random.nextBoolean())
  if (random.nextBoolean())
    System.out.println("1");
  else
    System.out.println("2");
else
  if (random.nextBoolean())
    System.out.println("3");
  else
    System.out.println("4");
System.out.println("done");
```

Two Choices



0
Thd0:java/util/Random.java:-1
Thd0:java/util/Random.java:-1
1
3
Thd0:TwoChoices.java:3
Thd0:TwoChoices.java:3
Thd0:TwoChoices.java:3
Thd0:TwoChoices.java:3
2

Two Choices


0
Thd0:java/lang/System.java:49
1
Thd0:java/lang/System.java:49
2
Thd0:java/lang/System.java:49
3