Daniel Schäfer (2549458)
Kevin Müller (2550062)
Rafael Dewes (2548365)

Embedded Systems Problem Set E

Problem E1

E1 5
E2 0
E3 9

Σ 14

a)

The path
(7, 8, 9, 1, 2, 3, 4, 5, 3, 4, 6)
has statement coverage,
but we do not cover the decision to follow the edge from 7 to 9.
As such we do not get decision coverage. ✓

b)

(2, 7, 8) is a simple path as it is finite and the nodes are pairwise different. It is also a subsequence of the prime path (1, 2, 7, 8, 9, 1). Thus the path itself is no prime path. ✓

c)

The following set of paths
{(1, 2, 7, 9, 1, 2, 3, 4, 5, 3), (1, 2, 7, 8, 9, 1, 2, 3, 4, 6)}
achieves prime path coverage. ✓

d)

1,

For path coverage of all finite paths the infinite set of test paths that fulfill the following suffice: $\{p \in [\ (1, 2, 7, ((8, \mid 8, 9,))^*\ 2, (3, 4, 5,)^*\ 3, 4, 6\ ]\ \}$; where * denotes any finite amount of repetitions

No edge from 8 or 9 to 2. -1

The given CFG contains two loops that allow for infinite paths. Since we cannot cover all infinite paths with our test paths, we do not have full path coverage.

This infinte set covers all finite paths, therefore we do achieve prime path coverage. ✓

Scanned with CamScanner

Daniel Schäfer (2549458)
Kevin Müller (2550062)
Rafael Dewes (2548365)

b)

i) $\mathbf{G}(\neg\, bdep)$ ✓

ii) $\mathbf{G}(\neg home \rightarrow \mathbf{F}\, home)$ ✓

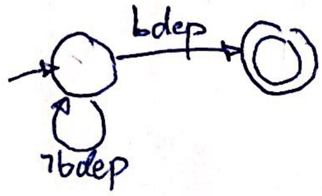
iii) $\mathbf{G}(pu2 \rightarrow (\neg pu1\; \mathbf{U}\; compacting))$ ✓

iv) $\mathbf{G}(fis \rightarrow \mathbf{X}\, puf)$ ✗

3/4

c)

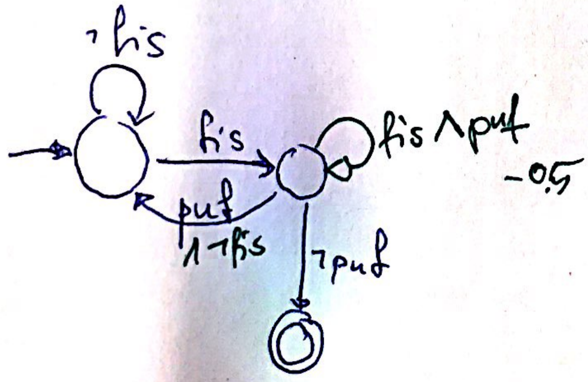
i) safety property, any prefix with bdep is bad prefix.
automaton: ✓

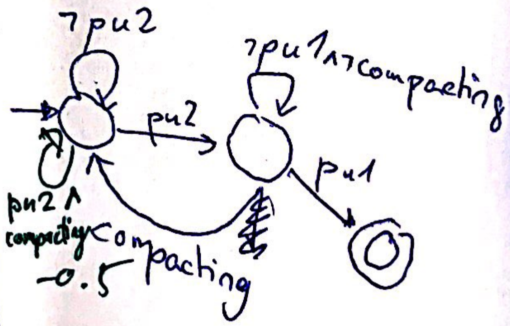


ii) liveness property, we can "fix" any execution by adding home. ✓

iii) ~~liveness~~ safety property ✓ bad prefix for any execution if pu1 ~~happens~~ occurs after pu2 and before compacting

iv) safety property, if we have fis and the next state is not puf → bad prefix.





6/7

$\boxed{E1}$

find all prime paths:

7 → 8 9 1 2 3 4 5 ①
7 → 9 1 2 3 4 5 ②
7 8 9 1 2 3 4 6 ③
7 9 1 2 3 4 6 ④

circularity shifted
1 2 7 8 9 1 ⑤
1 2 7 9 1 ⑥
3 4 5 3 ⑦

5 3 4 6 ⑧

$\Box\varphi$ globally
$\Diamond\varphi$ eventually
$\varphi U \psi$ until

build minimal sets of paths

⑤/⑥ ⑦

1 2 7 (8) 9 1 2 3 4 5 3 4 6 (2 paths!)

①/② ⑧

$\underbrace{7\ (8)\ 9\ 1\ 2\ 3\ 4\ 6}_{③/④}$ (2 paths!)

given as regular expression: where $m,n \geq 0$

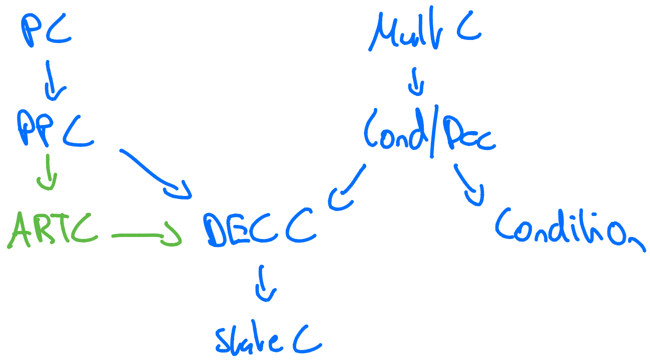
$$1\,2\left[\left(7\,(8)^{0/1}\,9\,1\,2\right)^n 3\,4\left(\left(5\,3\,4\right)^m \mid 6\right)\right]$$

$\boxed{\text{E2}}$

Problem E2: Coverage Hierarchy (4 Points)
Consider the *Hierarchy of CFG Coverage Criteria* on slide 35 in lecture 10. The *All-Round-Trip-Coverage* metric M_{rt} requires that each edge is covered and each loop is traversed at least once.

Pin down the correct place for the All-Round-Trip-Coverage in the hierarchy. For all direct predecessors M_p of M_{rt} and direct successors M_s of M_{rt}, prove

$$M_p \implies M_{rt} \text{ and } M_{rt} \implies M_s$$



PP C → ARTC

- for all edges : extend to prime path
- for each loop: loop itself is a prime path (→ already included)

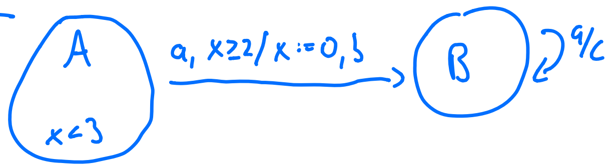
ARTC → DEC C

- all edges included → all decisions included.

$\boxed{E3}$ a)

compare to natural numbers (not each other)

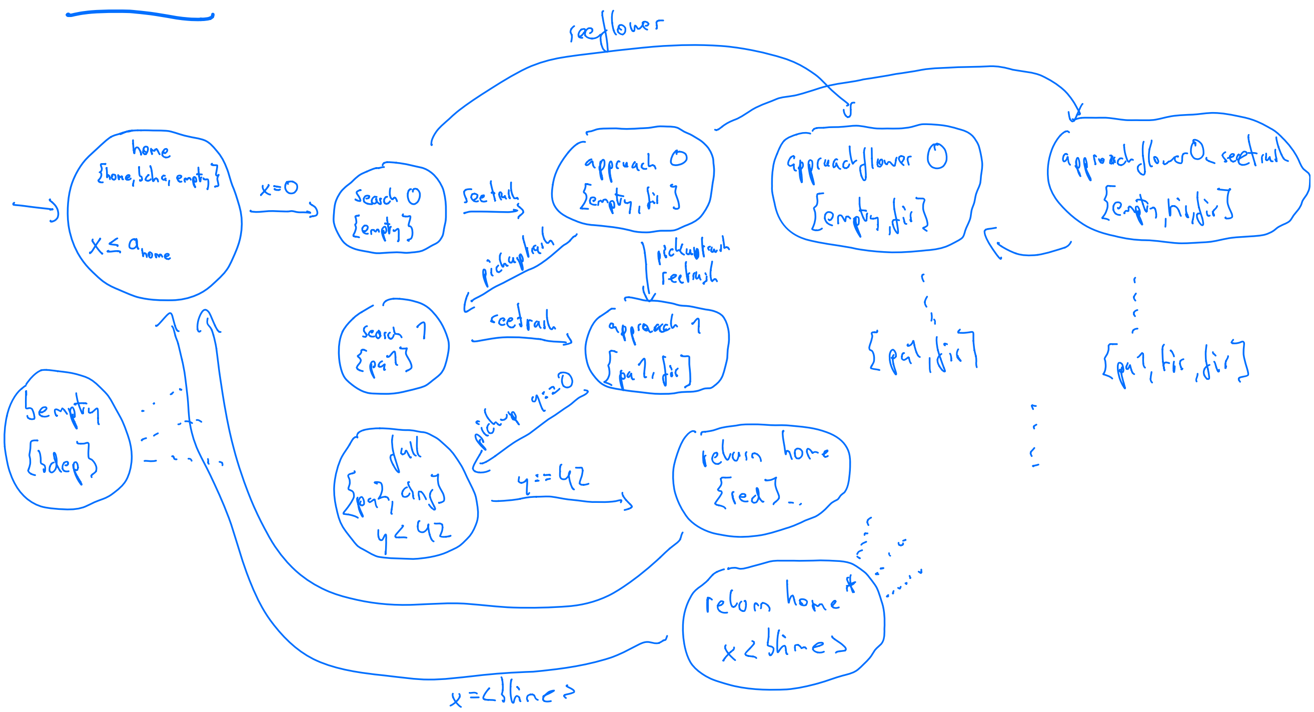
Example:



$$\langle A, x=2\rangle \xrightarrow{a/b} \langle B, x=0\rangle, \langle B, x=0\rangle \xrightarrow{a/c} \langle B, x=0\rangle$$

$$\langle A, x=0\rangle \xrightarrow{7} \langle A, x=2.1\rangle \xrightarrow{a/b} \langle B, x=2.1\rangle \xrightarrow{7} \langle B, x=9.1\rangle$$

Exercise:



invariant of battery drained defined afterwards:

for all states, except home, bempty:

invariant: $x < btime$

transition to bempty guarded by $x = btime$

- criterion to drive same way home is only possible to drive home if battery half empty.

[Invariant: $x < \frac{btime}{2}$

transitions: return to home guarded by $x = \frac{btime}{2}$

b) S i) $G(\neg bdep)$ (if not specified (red above) would only need first state)

L ii) $G(\neg home \rightarrow F\, home)$

↳ this means that compressing eventually happens

Neither iii) $G(pu2 \rightarrow (\neg(pu1 \vee pu2)\ U\ cing))$

restrict automaton to not have 2 pu2 in succession

S Improved: $G(pu2 \rightarrow (\neg(pu1 \vee pu2)\ W\ cing))$

$\phi W \psi \equiv (\phi U \psi) \vee G \phi$

$\Longrightarrow G(pu2 \rightarrow X[(\neg(pu1 \vee pu2)\ U\ cing) \vee G(\neg(pu1 \vee pu2))])$

L iv) $G(fis \rightarrow F\, puf)$

c) see submission corrected!

iii)