C340 Concurrency: Liveness & Progress

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Outline

- Liveness
- Progress
- Progress Specification in FSP
- Progress-Analysis of LTS
- Priorities

Motivation

- *Problem with single lane bridge:*
- *Cars cannot pass from north to south if there is a continuous stream of cars from south to north!*
- *We would like to guarantee that cars will eventually cross the bridge.*
- *In more general terms this is referred to as liveness*

Liveness

- *A liveness property asserts that something good eventually happens.*
- *We want to specify liveness for our FSP models*
- *We want to analyze our FSP models to be certain that the liveness properties hold*
- *General form of liveness requires consideration of temporal precedence relationship between states*
- *We use more restricted form of progress*

Progress

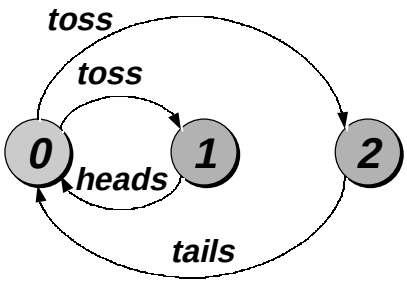
- *A progress property asserts that whatever state a system is in, it is always the case that a specified action will eventually be executed*
- *Progress is the opposite form of starvation*
- *Notion of progress is sufficiently powerful to capture wide range of liveness properties*
- *Progress properties are simple to specify in FSP*

Progress Properties in FSP

- *Specification of progress needs assumption of a fair scheduling policy.*
- *If a transition from a set is chosen infinitely often and every transition in the set will be executed infinitely often, the scheduling policy is said to be fair.*
- `progress P={a1,a2,…,an}` *defines a progress property* `P` *which asserts that in an infinite execution at least one of the actions* `a1, a2, …, an` *will be executed infinitely often.*

Example: Tossing Coins

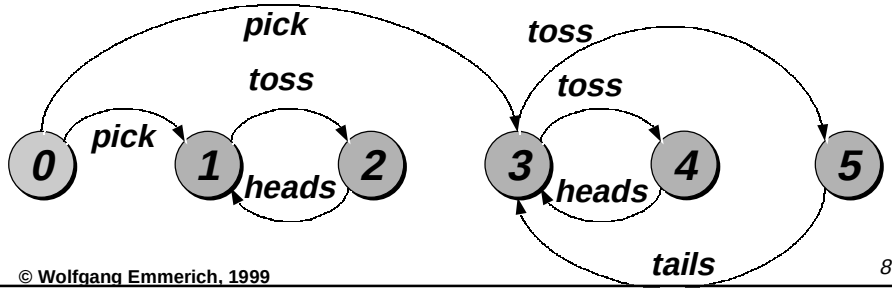
```
COIN = ( toss -> heads -> COIN
       | toss -> tails -> COIN).
```




```
progress HEADS = {heads}
progress TAILS = {tails}
```


Example: Tossing Trick Coins

```
TWOCOIN = (pick->COIN | pick->TRICK),
COIN    = ( toss -> heads -> COIN
          | toss -> tails -> COIN),
TRICK   = (toss->heads->TRICK).
progress HEADS = {heads}
progress TAILS = {tails}
```



Progress Analysis

- *We can automate analysis of progress properties*
- *A set of states where every state is reachable from every other state in the set and no state has transitions to states outside the set is a terminal set of states.*
- *Terminal set of states can be found using a graph algorithm that searches for a strongly connected component.*

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Default Progress Properties

- *Default progress properties assert in a system with fair choices that every action in the alphabet will be executed infinitely often.*
- *Default progress properties of example:*

```
progress p1 = {pick}
progress p2 = {toss}
progress p3 = {heads}
progress p4 = {tail}
```

- *How many violations?*

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Priorities

- *Default progress analysis of single lane bridge does not reveal violation.*
- *Problem is scheduling policy. Cars arriving in the south get 'priority' if there are already northbound cars on the bridge*
- *To detect such progress violations we have to reflect such priorities in the FSP model*

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High Priority in FSP

- `||C = (P||Q)<<{a1,…,an}` *specifies a composition in which the actions* `a1,…,an` *have higher priority than any other action in the alphabet of* `P||Q` *including the silent action* `tau`*. In any choice in this system which has one or more of the actions a1,…,an labelling a transition, the transitions labelled with lower priority actions are discarded.*

Low Priority in FSP

- `||C = (P||Q)>>{a1,…,an}` ***specifies a composition in which the actions*** `a1,…,an` ***have lower priority than any other action in the alphabet of*** `P||Q` ***including the silent action*** `tau`***. In any choice in this system which has one or more transitions not labelled by*** `a1,…,an`***, the transitions labelled by*** `a1,…,an` ***are discarded.***

Simplification of LTS

- ***Priorities simplify the LTS resulting of the composition.***
- ***Example:***

```
NORMAL=(work->play->NORMAL
        |sleep->play->NORMAL).
||HIGH=(NORMAL)<<{work}.
||LOW= (NORMAL)>>{work}.
```

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- ***Use of priorities lead to more realistic liveness checks.***

Summary

- *Liveness*
- *Progress*
- *Progress Specification in FSP*
- *Progress-Analysis of LTS*
- *Priorities*
- *Next session: Progress Analysis of Single-Lane Bridge*