Examples for Testing of the MIcroSimulation Tool (MIST)

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ADDITIONAL CLARIFICATION

Introduction

This document contains a set of examples that demonstrates the simulation capabilities of the MIcroSimulation Tool (MIST). These capabilities are demonstrated by a set of examples that are presented in increasing level of complexity. These tests have known results and are used for testing the system integrity. In addition to the example descriptions, the results of each example are shown and the appendix for this document contains programs that show how these results were calculated.

These examples are incorporated in the file InputExample.py to verify system integrity. They are also shown in the file testing.zip that can be loaded by the system.

Each example in this file is shown in the following format:

Example #: The example title and number

Model

Containing the diagram that shows the states and transitions. Transition probabilities are presented below the diagram.

Population:

Defines the structure of the population the simulation works on.

Simulation Rules:

Defines additional simulation rule that can be added to the simulation. Also defined are the Number of Repetitions and the Max Time Iterations / simulation steps.

Expected Outcome:

Contains the expected outcome. Usually this includes the mean counts of population at each stage at the end of simulation. The appendix at the end of the document contains Matlab code that calculates these means. In addition, to these expected outcomes, each example may contain additional tests that verify integrity of the example. These tests are implemented in the verification script InputExample.py.

For further information about the project, please visit the author web site: http://sites.google.com/site/jacobbarhak/

Examples for Simulation Module Testing

Example 1: Simple Example:

Model

Alive $\xrightarrow{P_0}$ Dead

Where:

$p_0 = 0.0717$

Population:

10 Individuals with the following characteristics:

All Alive except one, all with Age = 30

Simulation Rules:

Phase 1: Covariate Update:

Age = Age +1

Phase 3: Treatment Update:

None

Phase 4: Cost/QoL Update:

None

Number of Repetitions: 100

Max Time Iterations: 3

Expected Outcome:

- Age in all alive people should be 33.
- Average age at death = 31.2540
- Distribution at the end of simulation:
  - 719.9587 Alive
  - 280.0413 Dead

Example 2: Multiple Transitions in a Chain

Model

$$\boxed{0} \xrightarrow{P_0} \boxed{1} \xrightarrow{P_1} \boxed{2}$$

Where:

$p_0 = 0.1$

$p_1 = 0.2$

Population:

2 Individuals with the following characteristics:

1 in state 0, 1 in state 1

Age = 30

Simulation Rules:

Phase 1: Covariate Update:

Age = Age +1

Phase 3: Treatment Update:

None

Phase 4: Cost/QoL Update:

None

Number of Repetitions: 500

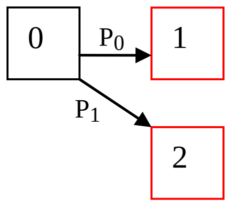
Max Time Iterations: 5

Expected Outcome:

- Distribution at the end of simulation:
  - 295.2450 State 0,
  - 295.2450 State 1
  - 409.5100 State 2
- Age in all alive people should be 35.

Example 3: A fork state

Model



Where:

$p_0 = 0.3$

$p_1 = 0.6$

Population:

1 Individual with the following characteristics:

All in state 0

Age = 30

Simulation Rules:

Phase 1: Covariate Update:

Age = Age +1

Phase 3: Treatment Update:

None

Phase 4: Cost/QoL Update:

None

Number of Repetitions: 1000

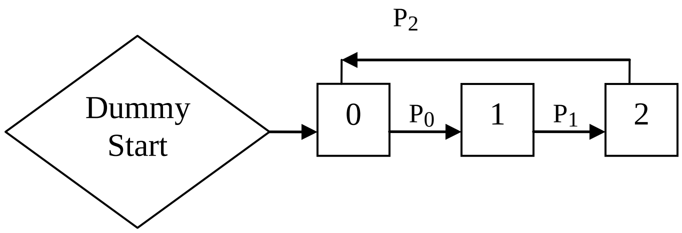
Max Time Iterations: 2

Expected Outcome:

- At the end of simulation, the distribution should be:
  - 10.0000 State 0
  - 330.0000 State 1
  - 660.0000 State 2

Example 4: Funny Loop Example

Model



Where:

$p_0 = 0.1$

$p_1 = 0.2$

$p_2 = 0.3$

Population:

3 Individuals with the following characteristics:

Age = 30 Starting at state 0
Age = 40 Starting at state 1
Age = 50 Starting at state 2

Simulation Rules:

Phase 1: Covariate Update:
Age = Age +1
Phase 3: Treatment Update:
None
Phase 4: Cost/QoL Update:
None

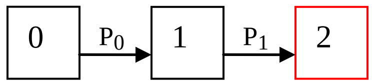
Number of Repetitions: 500
Max Time Iterations: 5

Expected Outcome:

- The Dummy Start Event state is never entered or set as it exists as a start indicator alone, rather than a meaningful state.
- All Individuals should be at ages 35, 45, 55 – no termination before the end
- At the end of simulation, the distribution should be:
  - 791.1000 State 0
  - 393.1950 State 1
  - 315.7050 State 2

Example 5a: Multiple Transitions in a Chain with an Expression and Boolean Covariate - (Extending the example from figure 2d in Isaman, 2006)

Model



Where:

p_0 = exp(-(b_o+b_1*Z))   Z Gender   b_o=.4 b_1=.3

p_1 = exp(-(g_o+g_1*Z))   Z Gender   g_o=.4 g_1=.5

Population:

1 man (Z=1) starting at state 0
1 woman (Z=0) starting at state 0
ages should be irrelevant in this example

Simulation Rules:

Phase 1: Covariate Update:
None
Phase 3: Treatment Update:
None
Phase 4: Cost/QoL Update:
None

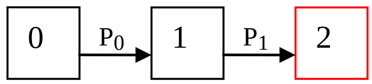
Number of Repetitions: 1000
Max Time Iterations: 2

Expected Outcome:

- Distribution at the end of simulation:
  - 253.4264 men, 108.6889 women in State 0
  - 544.6771 men, 441.9822 women in State 1
  - 201.8965 men, 449.3290 women in State 2

Example 5b: Multiple Transitions in a Chain with an Expression and Continuous Covariate - (Extending the example from figure 2d in Isaman, 2006)

Model



Where:

$p_0 =$ exp(-(b_o+b_1*Z)) Z Age b_o=.04 b_1=.03

$p_1 =$ exp(-(g_o+g_1*Z)) Z Age g_o=.04 g_1=.05

Population:

1 man (Z=45) starting at state 0
1 woman (Z=60) starting at state 0
gender should be irrelevant in this example

Simulation Rules:

Phase 1: Covariate Update:
Age=Age+1
Phase 3: Treatment Update:
None
Phase 4: Cost/QoL Update:
None

Number of Repetitions: 1000
Max Time Iterations: 2

Expected Outcome:

- Distribution at the end of simulation:
  - 580.4146 men (age=47), 719.3598 women (age=62) in State 0
  - 397.4372 men, and 273.9693 women in State 1
  - 22.1482 men, and 6.6709 women in State 2

Example 6: Multiple Transitions in a Long Chain with an Expression Containing a Continuous Covariate - (Extending the example from figure 2a,2b in Isaman, 2006)

Model

$$\boxed{0} \xrightarrow{P_0} \boxed{1} \xrightarrow{P_1} \boxed{2} \xrightarrow{P_2} \boxed{3}$$

Where:

p_0 = exp(-(b_o+b_1*Z)) Z Age b_o=.04 b_1=.03

p_1 = exp(-(g_o+g_1*Z)) Z Age g_o=.04 g_1=.05

p_2 = exp(-(g_o+g_1*Z)) Z Age g_o=.04 g_1=.05

Population:

1 man (Z=45) starting at state 0

1 woman (Z=60) starting at state 0

Simulation Rules:

Phase 1: Covariate Update:

Age=Age+1

Phase 3: Treatment Update:

None

Phase 4: Cost/QoL Update:

None

Number of Repetitions: 10000

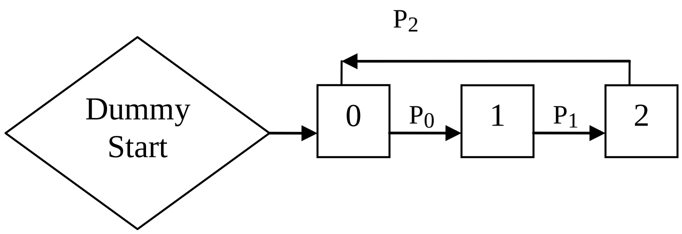
Max Time Iterations: 3

Expected Outcome:

- Distribution at the end of simulation:
  - 4482.904 men (age=48), 6149.460 women (age=63) in State 0
  - 4949.205 men, and 3671.033 women in State 1
  - 548.587 men, and 176.761 women in State 2
  - 19.305 men, and 2.747 women in State 3

Example 7: Funny Loop Example with an Expression - (Extending the example from figure 2c in Isaman, 2006)

Model



Where:

$p_0 =$ exp(-(b_o+b_1*Z))   Z Age   b_o=.02 b_1=.02

$p_1 =$ exp(-(g_o+g_1*Z))   Z Age   g_o=.02 g_1=.01

$p_2 =$ exp(-(g_o+g_1*Z))   Z Age   g_o=.02 g_1=.01

Population:

1 man (Z=45) starting at state 0

1 woman (Z=60) starting at state 0

Simulation Rules:

Phase 1: Covariate Update:

Age=Age+1

Phase 3: Treatment Update:

None

Phase 4: Cost/QoL Update:

None

Number of Repetitions: 1000

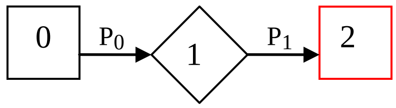
Max Time Iterations: 3

Expected Outcome:

- Distribution at the end of simulation:
  - 380.0611 men (age=48), 447.1718 women (age=63) in State 0
  - 292.4802 men, and 303.2561 women in State 1
  - 327.4586 men, and 249.5721 women in State 2

Example 8: An Event State in a Chain

Model



Where:

$p_0 = 0.0717$

$p_1 = 1$

Population:

10 Individuals with the following characteristics:

All in states 0 except one at state 2. all with Age = 30,

Simulation Rules:

Phase 1: Covariate Update:

Age = Age +1

Phase 3: Treatment Update:

None

Phase 4: Cost/QoL Update:

None

Number of Repetitions: 100

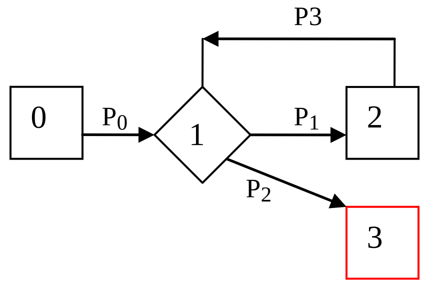
Max Time Iterations: 3

Expected Outcome:

- Similar to Example 1
- The Event state indicator is never set in the results.
- The Entered indicator of the event state remains set at the transition to the final state.

Example 9: Combined Fork Loop and Event state

Model



Where:

$p_0 = 0.1$

$p_1 = 0.8$

$p_2 = 1 - p_1 = 0.2$

$p_3 = 0.1$

Population:

10 Individuals with the following characteristics:

4 in State 0, Age = 40

5 in State 2, Age = 50

1 in State 3, Age = 60

Simulation Rules:

Phase 1: Covariate Update:

Age = Age +1

Phase 3: Treatment Update:

None

Phase 4: Cost/QoL Update:

None

Number of Repetitions: 100

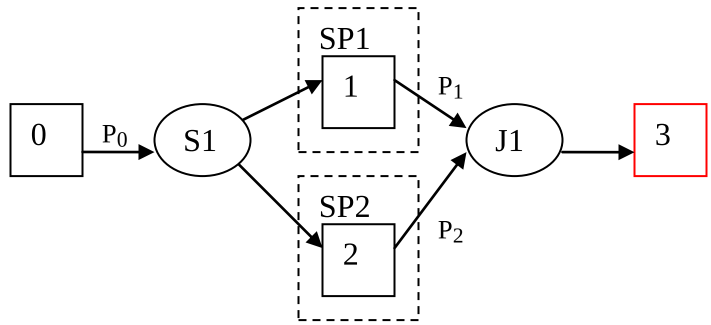
Max Time Iterations: 10

Expected Outcome:

- No individuals in the event state
- The event State indicator for Entered is set for every transition the occurred and is reset otherwise
- Distribution at the end of simulation:
    - 139.4714 at State 0
    - 595.8942 at State 2
    - 264.6345 at State 3

Example 10: Split, Join, Simple Test

Model



Where:

$p_0 = 0.1$

$p_1 = p_2 = 1 - \frac{2}{5}\sqrt{5}$. Note that $p_1 + p_1(1 - p_1) = 0.2$ as in example 2

Population:

2 Individuals with the following characteristics:

1 in state 0, 1 in states 1 and 2 together

Age = 30

Simulation Rules:

Phase 1: Covariate Update:

Age = Age +1

Phase 3: Treatment Update:

None

Phase 4: Cost/QoL Update:

None

Number of Repetitions: 500

Max Time Iterations: 5

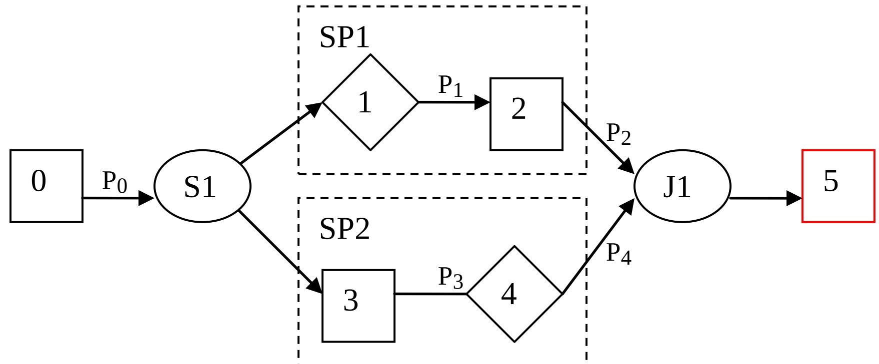
Expected Outcome:

- Similar to the results of example 2, where state 3 corresponds to state 2 in Example 2 and all states and subprocesses SP1 and SP2 both correspond to State 1 in Example 2. Note that the number of people in the subprocess should be counted to figure out if the population sum is correct as states may remain set at the time of reaching the terminal state.
- The subprocess indicators for Sp1 and Sp2 are equal
- The main subprocess indicator is always set
- If the state indicator in state 1 or 2 are set, then the other one and the indicators for the subprocesses SP1 and SP2 are also set, unless the indicator for the terminal state is set, in which case, the other one is reset and both subprocess states are reset. All States may be reset.

- If a subprocess indicator in SP1, SP2 are set, then state indicators 1 and 2 are set.
- The entered indicators of the subprocess and the subprocess states equal to the entered indicator of the splitter state
- The indicator of the splitter and joiner states are never set
- The entered indicator of the joiner state is equal to the terminal state indicator which is equal to the entered indicator of the terminal state.

Example 11: Split, Join, and Event Test

Model



Where:

$p_0 = 0.1$

$p_1 = 1$

$p_2 = p_3 = 1 - \frac{2}{5}\sqrt{5}$ Note that $p_2 + p_2(1 - p_2) = 0.2$ as in example 2

$p_4 = 1$

Population:

2 Individuals with the following characteristics:

1 in state 0, 1 in states 2 and 3 together

Age = 30

Simulation Rules:

Phase 1: Covariate Update:

Age = Age +1

Phase 3: Treatment Update:

None

Phase 4: Cost/QoL Update:

None

Number of Repetitions: 500

Max Time Iterations: 5

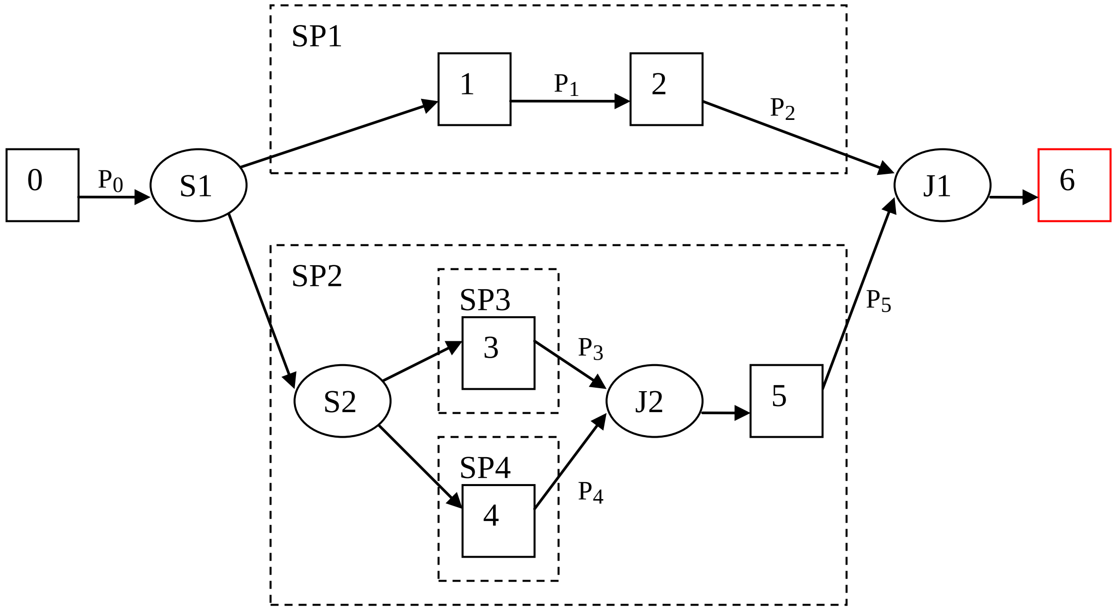
Expected Outcome:

- Similar to the results of example 2, where state 5 corresponds to state 2 in Example 2 and all states and subprocesses SP1 and SP2 both correspond to State 1 in Example 2. Note that the number of people in the subprocess should be counted to figure out if the population sum is correct as states may remain set at the time of reaching the terminal state.

- The subprocess indicators for Sp1 and Sp2 are equal
- The main subprocess indicator is always set
- If the state indicator in state 2 or 3 are set, then the other one and the indicators for the subprocesses SP1 and SP2 are also set, unless the indicator for the terminal state 5 is set, in which case, the other one is reset and both subprocess states are reset. All States may be reset.
- If a subprocess indicator in SP1, SP2 are set, then state indicators 2 and 3 are set.
- State 3 and state 5 are never set together unless state 2 is reset
- The entered indicators of the subprocesses and states 1,2,3 equal to the entered indicator of the splitter state
- The indicator of the splitter, joiner, and event states are never set
- The entered indicator of the joiner state is equal to the terminal state indicator which is equal to the entered indicator of the terminal state.

Example 12: Nested split/join test

Model



Where:

$$p_0 = 0.1$$

$$p_1 = 0.2$$

$$p_2 = p_5 = 1 - \sqrt{7/10} \text{ Note that } p_2 + p_2(1 - p_2) = 0.3$$

$$p_3 = p_4 = 1 - \frac{2}{5}\sqrt{5} \text{ Note that } p_3 + p_3(1 - p_3) = p_1$$

Population:

2 Individuals with the following characteristics:

Age = 30

One starts in state 0 and one in states 1,3,4.

Simulation Rules:

Phase 1: Covariate Update:

Age = Age +1

Phase 3: Treatment Update:

None

Phase 4: Cost/QoL Update:

None

Number of Repetitions: 500

Max Time Iterations: 10

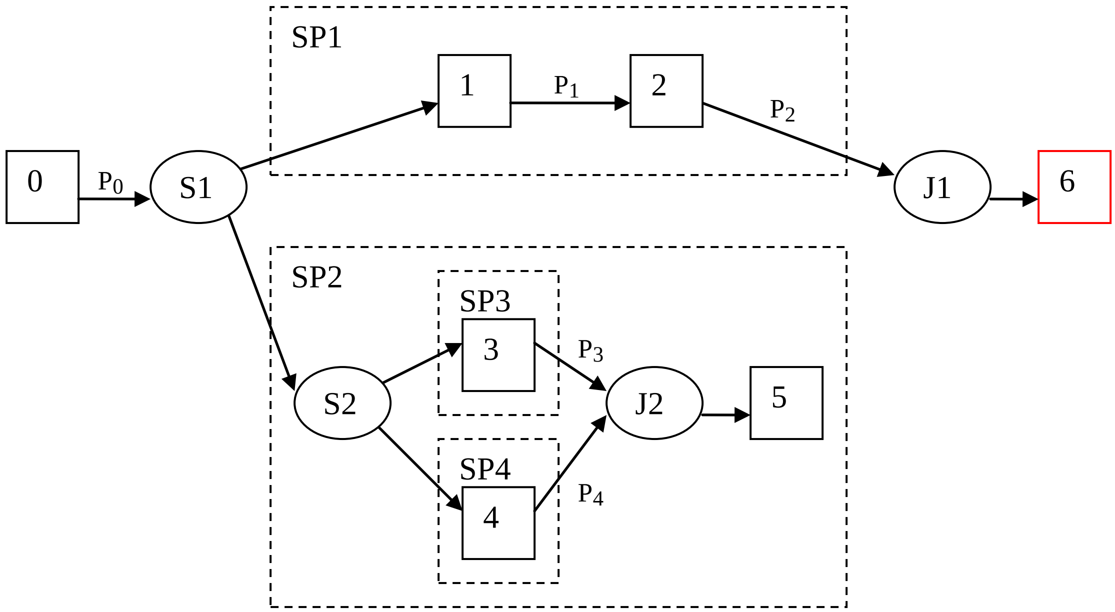
Expected Outcome:

- At the end of simulation, the distribution should be:
  - 174.3392 State 0
  - 125.6437 State 1 while SP1 is set
  - 157.7785 State 2 while SP1 is set
  - 542.2386 State 6

- Age of all alive people should be 40
- The number of people only in active processes should be counted to figure out if the population sum is correct as states may remain set at the time of reaching the terminal state.
- The subprocess indicators for Sp1 and Sp2 are equal
- The subprocess indicators for Sp3 and Sp4 are equal
- The main subprocess indicator is always set
- If the state indicator in state 1 or 3 are set, then the indicators for the subprocesses SP1 and SP2 are also set, unless the indicator for the terminal state 6 is set, in which case, both subprocess states are reset. All States may be reset, also both subprocesses may be set together without setting states 1,3.
- If a subprocess indicator in SP1, SP2 are set, then state indicators (1 or 2) and (3 or 4 or 5) are set, while 3,4,5 are never set together. Also 2,3,4,5,6 can be set without SP1 and SP2 begin set.
- State 3 and state 6 are never set together unless state 2 is reset
- States 3,4,5 are never all set together.
- The entered indicators of subprocesses SP1, SP2, SP3, SP4 and states 1,3,4 equal to the entered indicator of the splitter states S1 and S2.
- The indicator of the splitter and joiner states S1, S2, J1, J2 are never set
- The entered indicator of the joiner state J1 is equal to the terminal state indicator which is equal to the entered indicator of the terminal state 6.

Example 13: Split and join test without termination in a subprocess

Model



Where:

$$p_0 = 0.1$$
$$p_1 = 0.2$$
$$p_2 = 0.3$$
$$p_3 = p_4 = 1 - \frac{2}{5}\sqrt{5} \text{ Note that } p_3 + p_3(1 - p_3) = p_1$$

Population:

2 Individuals with the following characteristics:

Age = 30

One starts in state 0 and one in states 1,3,4.

Simulation Rules:

Phase 1: Covariate Update:

Age = Age +1

Phase 3: Treatment Update:

None

Phase 4: Cost/QoL Update:

None

Number of Repetitions: 500

Max Time Iterations: 10

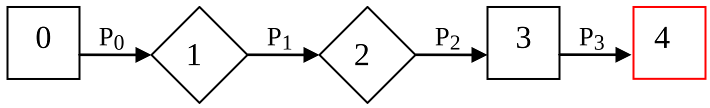
Expected Outcome:

- At the end of simulation, the distribution should be:
  - 174.3392 State 0
  - 174.3392 State 1 while SP1 is set
  - 160.2155 State 2 while SP1 is set
  - 491.1061 State 6

- Age of all alive people should be 40
- The number of people only in active processes should be counted to figure out if the population sum is correct as states may remain set at the time of reaching the terminal state.
- The subprocess indicators for Sp1 and Sp2 are equal
- The subprocess indicators for Sp3 and Sp4 are equal
- The main subprocess indicator is always set
- If the state indicator in state 1 or 3 are set, then the indicators for the subprocesses SP1 and SP2 are also set, unless the indicator for the terminal state 6 is set, in which case, both subprocess states are reset. All States may be reset, also both subprocesses may be set together without setting states 1,3.
- If a subprocess indicator in SP1, SP2 are set, then state indicators (1 or 2) and (3 or 4 or 5) are set, while 3,4,5 are never set together. Also 2,3,4,5,6 can be set without SP1 and SP2 begin set.
- State 3 and state 6 are never set together unless state 2 is reset
- States 3,4,5 are never all set together.
- The entered indicators of subprocesses SP1, SP2, SP3, SP4 and states 1,3,4 equal to the entered indicator of the splitter states S1 and S2.
- The indicator of the splitter and joiner states S1, S2, J1, J2 are never set
- The entered indicator of the joiner state J1 is equal to the terminal state indicator which is equal to the entered indicator of the terminal state 6.
- If State 6 is set then either State 5 or State 4 are also set. In other words, there is no path from state 5 to state 6 and State 6 can be reached only from state 2.

Example 14: Multiple events

Model



Where:

$p_0 = p_1 = p_2 = p_3 = 1$

Population:

1 Individual in State 0

Simulation Rules:

Phase 1: Covariate Update:
None
Phase 3: Treatment Update:
None
Phase 4: Cost/QoL Update:
None

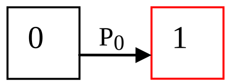
Number of Repetitions: 100
Max Time Iterations: 1

Expected Outcome:

- Distribution at the end of simulation:
  - 100 in State 3
  - 100 with State 1 Entered and State 2 Entered
  - 0 in State 1, 2, 4

Example 15: Simple Table Example

Model



Where:

p_0 is defined by the following table

	Gender = 0	Gender =1
Age≤ 20	0.1	0.4
20<Age≤40	0.2	0.5
40<Age	0.3	0.6

Population:

6 Individuals all alive with the following characteristics:

- Gender = 0, Age =5
- Gender = 0, Age =25
- Gender = 0, Age =45
- Gender = 1, Age =5
- Gender = 1, Age =25
- Gender = 1, Age =45

Simulation Rules:

Phase 1: Covariate Update:
Age = Age +1
Phase 3: Treatment Update:
None
Phase 4: Cost/QoL Update:
None

Number of Repetitions: 100
Max Time Iterations: 3

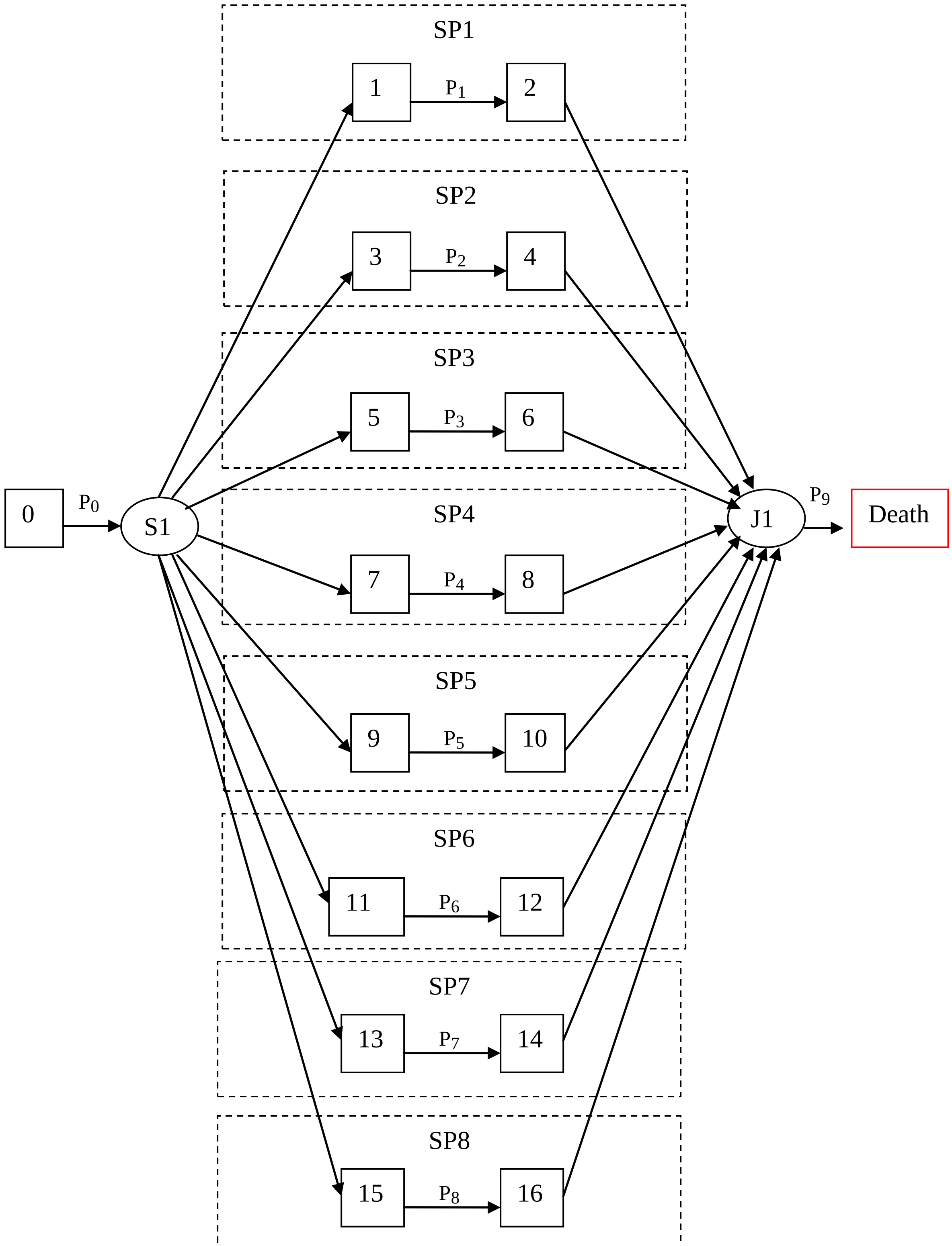
Expected Outcome:

- Age in all people in state 0 should be either 8,28,48.
- Distribution at the end of simulation:
  - 198.9000 in State 0
  - 401.1000 in State 1
- Distribution at the end of simulation where Gender =0 is:
  - 158.4000 in State 0
  - 141.6000 in State 1
- Distribution at the end of simulation where Age≤ 20 is:
  - 94.5000 in State 0
  - 105.5000 in State1

- Distribution at the end of simulation where $20 < \text{Age} \leq 40$ is:
    - 63.7000 in State 0
    - 136.3000 in State 1

Example 16: Function test

Model



Where:

$p_0 = 1$

$p_1 =$ Le(Ls(Eq(Eq(-1,-1),Ne(-1,1)),1),0) * Not(Or(0,0)+And(0,1)) * IsTrue(.1) * .5

$p_2 =$ Ge(Gr(1,1),0)*Or(0,0,0,1)*And(1,1,1,1)*.5

$p_3 =$ IsInvalidNumber(NaN) * IsInfinteNumber(-Inf) * Not(IsFiniteNumber(Inf)) * (1/Sqrt(Log(16,2)))

$p_4 =$ Ln(Exp(Max(.25,0,-3)+Min(.25,100,25)))

$p_5 =$ Pi()+1/Log10(10**2)- 3.1415926535897931

$p_6 =$ Abs(-.5)*Floor(1.9)*Ceil(.1)*Mod(3,2)

$p_7 =$ 4/Pow(2,3)

$p_8 = .5$

$p_9 = 1$

Note that p_1 through p_8 should all equal .5

Population:

One individual in state 0 with BP = 0

Simulation Rules:

Phase 1: Covariate Update:

```
BP = BP + Le(Ls(Eq(Eq(-1,-1),Ne(-
1,1)),1),0)*Not(Or(0,0)+And(0,1))*IsTrue(.1)*.5 +
Ge(Gr(1,1),0)*Or(0,0,0,1)*And(1,1,1,1)*.5 +
IsInvalidNumber(NaN)*IsInfiniteNumber(-
Inf)*Not(IsFiniteNumber(Inf))*(1/Sqrt(Log(16,2)))
+ Ln(Exp(Max(.25,0,-3)+Min(.25,100,25))) +
Pi()+1/Log10(10**2)-3.1415926535897931 + Abs(-
.5)*Floor(1.9)*Ceil(.1)*Mod(3,2) + 4/Pow(2,3) +
.5
```

Phase 3: Treatment Update:

None

Phase 4: Cost/QoL Update:

None

Number of Repetitions: 1,000

Max Time Iterations: 2

Expected Outcome:

- At the end of simulation, the distribution should be:
  - 500 in each of States 1 through 16
  - Final BP = ~8 always

Example 17: Tests Iif(), conditionals, and feedback to indicators

Model

$$\boxed{0} \xrightarrow{P_0} \boxed{1} \xrightarrow{P_1} \boxed{2} \xrightarrow{P_2} \boxed{3}$$

Where:

$p_0 = 1$
$p_1 =$ Iif(Gr(Age,32),1,0)
$p_2 =$ Iif(State2_Diagnosed, 1, 0)

Population:

1 Individual in State 0

Simulation Rules:

Phase 1: Covariate Update:

a. Age = Age + 1
b. If State0:
   Ex17TestCovariate = Ex17TestCovariate+1
c. Occurrence Probability = Iif(State0, 1, 0):
   Ex17TestCovariate2 = Iif(State0, Ex17TestCovariate2 + 1, Ex17TestCovariate2)

Phase 3: Treatment Update:

a. If State2:
   i. State2_Diagnosed = Iif(Gr(Age, 34), 1, 0)

Phase 4: Cost/QoL Update:

None

Number of Repetitions: 50
Max Time Iterations: 10

Expected Outcome:

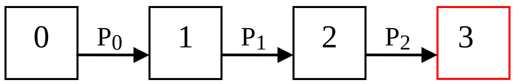
- Results according to the following table:

Iteration	0	1	2	3	4	5	6
Age	30	31	32	33	34	35	36
State0	1	0	0	0	0	0	0
State1	0	1	1	0	0	0	0
State2	0	0	0	1	1	1	0
State3	0	0	0	0	0	0	1
State2_Diagnosed	0	0	0	0	0	1	0
Ex17TestCovariate	0	1	1	1	1	1	1
Ex17TestCovariate2	0	1	1	1	1	1	1

- Distribution at the end of simulation:
  - 0 in State 0,1, 2
  - 50 in State 3

Example 18: Tests Cost/QoL Wizard

Model



Where:

$p_0 = 1$
$p_1 = 0.5$
$p_2 = 0.5$

Population:

1 Individual in State 0 , with Ex18TestCost = 10 and Ex18TestQoL = 0.1

Simulation Rules:

Phase 1: Covariate Update:
a. Age = Age + 1
Phase 3: Treatment Update:
None
Phase 4: Cost/QoL Update:
b. Ex18TestCost=CostWizard(0,100,[State1,State2],[Iif(Gr(Age,31),3,0),Iif(Gr(Age,33),2,0)])
c. Ex18TestQoL=CostWizard(1,.5,[State1,State2],[Iif(Gr(Age,31),.1,0),Iif(Gr(Age,33),.2,0)])
None

Number of Repetitions: 100
Max Time Iterations: 5

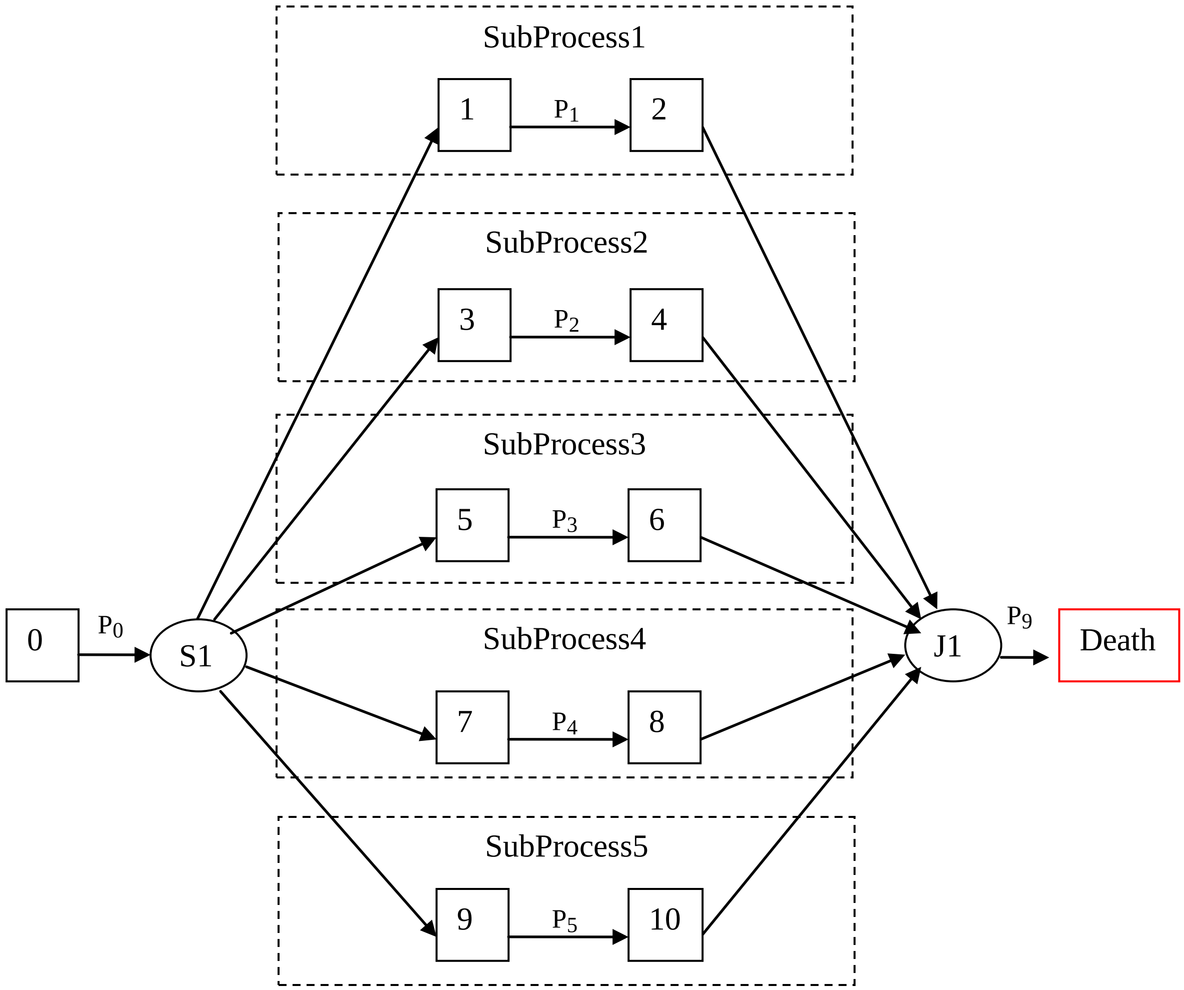
Expected Outcome:

- If state 1 and age>31 then:
  - Ex18TestCost = 100000 , Ex18TestQoL = 0.6
- If state 2 and age>33 then:
  - Ex18TestCost = 10000, Ex18TestQoL = 0.7
- If state 3 or (state 1 and age<=31) or (state 2 and age<=33) then:
  - Ex18TestCost = 100, Ex18TestQoL = 0.5
- If state 0 then:
  - Ex18TestCost = 10, Ex18TestQoL = 0.1

- Distribution at the end of simulation:
  - 0 in State 0
  - 6.25 in State 1
  - 25 in State 2
  - 68.75 in State 3

Example 19: Equivalent Parallel Process Test and Distribution Function Rule Test

Model



Where:

$p_0 = 1$

$p_1 = 0.5$

$p_2 = 0.5$

$p_3 = 0.5$

$p_4 = 0.5$

$p_5 = 0.5$

$p_9 = 1$

Note that p_1 through p_5 should all equal 0.5

Population:

One individual in state 0 with:

- CovTemp1=0
- CovTemp2=0
- CovTemp3=0
- CovTemp4=0
- CovTemp5=0

Simulation Rules:

Phase 1: Covariate Update:

- o TestCov1 = Le(Bernoulli(0.5), 0.5)
- o TestCov2 = Le(Binomial(3,0.5), 1)
- o TestCov3 = Le(Geometric(1-0.5**0.5), 2)
- o TestCov4 = Le(Uniform(0,2),1)
- o TestCov5 = Le(Gaussian(3,1), 3)

Phase 3: Treatment Update:

None

Phase 4: Cost/QoL Update:

None

Number of Repetitions: 1,000

Max Time Iterations: 2

Expected Outcome:

- At the end of simulation, the distribution should be:
  - o 500 in each of States 1 through 10
  - o At the end of simulation, the sum of each covariate over the population TestCov1..5 contains 500 individuals.

Example 20: Simple Example with Initial Population Defined by Distributions:

Model

Alive $\xrightarrow{P_0}$ Dead

Where:

$p_0 = 0.0717$

Population:

Individuals defined by distributions with the following characteristics:

Alive=Bernoulli(0.9)
Dead=1-Alive
Age ~ Min(Max(20,Gaussian(30,5)),40)

Simulation Rules:

Phase 1: Covariate Update:
Age = Age +1
Phase 3: Treatment Update:
None
Phase 4: Cost/QoL Update:
None

Number of Repetitions: 1000 (defines population size)
Max Time Iterations: 3

Expected Outcome:

- Age in all records should be between 20 and 43.
- There should be 25 individuals at age 20 - check this is correct within 3 STD
- Distribution at the end of simulation - Same as example 1:
    - 719.9587 Alive
    - 280.0413 Dead

APPENDIX:
Matlab code to generate the mean expected results

```
% This file contains analytic results to which the simulation results
% should be compared to.

% Example 1:  Simple Example:
disp ('*****************************************************')
disp ('*****************************************************')
disp ('*****************************************************')
disp ('Example 1:  Simple Example:')
disp ('*****************************************************')
disp ('*****************************************************')
disp ('*****************************************************')
P0 = 0.0717
t = 3
Pop = [9 1]*100

Mat =  [1-P0 , P0; 0 , 1]

Result = Pop*(Mat^t)

OldDeadNum = 0
for i = 0:t,
    DeadNum = Pop*Mat^i;
    DeadAtYear(i+1) = DeadNum(2) - OldDeadNum;
    OldDeadNum = DeadNum(2);
end

AverageAgeAtDeath = sum((30+(0:t)).*DeadAtYear)/sum(DeadAtYear)

% Example 2:  Multiple Transitions in a Chain
disp ('*****************************************************')
disp ('*****************************************************')
disp ('*****************************************************')
disp ('Example 2:  Multiple Transitions in a Chain')
disp ('*****************************************************')
disp ('*****************************************************')
disp ('*****************************************************')

P0 = 0.1
P1 = 0.2

t = 5
Pop = [1 1 0]*500

Mat =  [1-P0 , P0 , 0 ; 0 , 1-P1, P1 ; 0, 0, 1]

Result = Pop*(Mat^t)
```

```
% Example 3:  A fork state
disp ('*****************************************************')
disp ('*****************************************************')
disp ('*****************************************************')
disp ('Example 3:  A fork state')
disp ('*****************************************************')
disp ('*****************************************************')
disp ('*****************************************************')

P0 = 0.3
P1 = 0.6

t = 2
Pop = [1 0 0]*100

Mat =  [1-P0-P1, P0 , P1 ; 0, 1, 0 ; 0, 0, 1]

Result = Pop*(Mat^t)


% Example 4: Funny Loop Example
disp ('*****************************************************')
disp ('*****************************************************')
disp ('*****************************************************')
disp ('Example 4: Funny Loop Example')
disp ('*****************************************************')
disp ('*****************************************************')
disp ('*****************************************************')

P0 = 0.1
P1 = 0.2
P2 = 0.3

t = 5
Pop = [1 1 1]*500

Mat =  [1-P0, P0 , 0 ; 0, 1-P1, P1 ; P2, 0, 1-P2]

Result = Pop*(Mat^t)



% Example 5a:  Multiple Transitions in a Chain with an Expression and
% Boolean Covariate
disp ('*****************************************************')
disp ('*****************************************************')
disp ('*****************************************************')
disp ('Example 5a:  Multiple Transitions in a Chain with an Expression
and Boolean Covariate')
disp ('*****************************************************')
disp ('*****************************************************')
disp ('*****************************************************')
```

```
MaxTime=2



for Gender = 0:1,
    Pop = [1 0 0]*1000
    MultMat = eye(3)
    for t= 1:MaxTime

        P0 = exp(-(0.4 + 0.3*Gender))
        P1 = exp(-(0.4 + 0.5*Gender))

        Mat =  [1-P0 , P0 , 0 ; 0 , 1-P1, P1 ; 0, 0, 1]
        MultMat = MultMat * Mat
    end
    disp (sprintf ('Results for Gender = %g', Gender))
    Result = Pop*(MultMat)
end


% Example 5b:  Multiple Transitions in a Chain with an Expression and
% Continuous Covariate - (Extending the example from figure 2d in
Isaman, 2006)
disp ('*****************************************************')
disp ('*****************************************************')
disp ('*****************************************************')
disp ('Example 5b:  Multiple Transitions in a Chain with an Expression
and Continuous Covariate')
disp ('*****************************************************')
disp ('*****************************************************')
disp ('*****************************************************')

MaxTime=2

Ages = [60,45]
for Gender = 0:1,
    Age = Ages(Gender+1)
    Pop = [1 0 0]*1000
    MultMat = eye(3)
    for t= 1:MaxTime
        Age = Age + 1
        P0 = exp(-(0.04 + 0.03*Age))
        P1 = exp(-(0.04 + 0.05*Age))
        Mat =  [1-P0 , P0 , 0 ; 0 , 1-P1, P1 ; 0, 0, 1]
        MultMat = MultMat * Mat
    end
    disp (sprintf ('Results for Gender = %g', Gender))
    Result = Pop*(MultMat)
end


% Example 6: Multiple Transitions in a Long Chain with an Expression
Containing a Continuous Covariate - (Extending the example from figure
2a,2b in Isaman, 2006))
disp ('*****************************************************')
```

```
disp ('*****************************************************')
disp ('*****************************************************')
disp ('Example 6:  Multiple Transitions in a Long Chain with an
Expression Containing a Continuous Covariate')
disp ('*****************************************************')
disp ('*****************************************************')
disp ('*****************************************************')

MaxTime = 3

Ages = [60,45]
for Gender = 0:1,
    Age = Ages(Gender+1)
    Pop = [1 0 0 0]*1000
    MultMat = eye(4)
    for t= 1:MaxTime
        Age = Age + 1
        P0 = exp(-(0.04 + 0.03*Age))
        P1 = exp(-(0.04 + 0.05*Age))
        P2 = exp(-(0.04 + 0.05*Age))
        Mat =  [1-P0 , P0 , 0 , 0 ; 0 , 1-P1, P1 ,0 ; 0, 0, 1-P2, P2;
0, 0, 0, 1]
        MultMat = MultMat * Mat
    end
    disp (sprintf ('Results for Gender = %g', Gender))
    Result = Pop*(MultMat)
end




% Example 7: Funny Loop Example with an Expression - (Extending the
example from figure 2c in Isaman, 2006)
disp ('*****************************************************')
disp ('*****************************************************')
disp ('*****************************************************')
disp ('Example 7: Funny Loop Example with an Expression - (Extending
the example from figure 2c in Isaman, 2006)')
disp ('*****************************************************')
disp ('*****************************************************')
disp ('*****************************************************')

MaxTime = 3

Ages = [60,45]
for Gender = 0:1,
    Age = Ages(Gender+1)
    Pop = [1 0 0]*1000
    MultMat = eye(3)
    for t= 1:MaxTime
        Age = Age + 1
        P0 = exp(-(0.02 + 0.02*Age))
        P1 = exp(-(0.02 + 0.01*Age))
        P2 = exp(-(0.02 + 0.01*Age))
        Mat =  [1-P0 , P0 , 0 ; 0 , 1-P1, P1 ; P2, 0, 1-P2]
```

```
        MultMat = MultMat * Mat
    end
    disp (sprintf ('Results for Gender = %g', Gender))
    Result = Pop*(MultMat)
end



% Example 9: Combined Fork Loop and Event state
disp ('*****************************************************')
disp ('*****************************************************')
disp ('*****************************************************')
disp ('Example 9: Combined Fork Loop and Event state')
disp ('*****************************************************')
disp ('*****************************************************')
disp ('*****************************************************')

P0 = 0.1
P1 = 0.8
P2 = 1 - P1
P3 = 0.1


t = 10
Pop = [4 5 1]*100

Mat =  [1-P0, P0*P1 , P0*P2 ; 0, 1-P3*P2, P3*P2 ; 0, 0, 1]

Result = Pop*(Mat^t)




% Example 12:  Nested split/join test
disp ('*****************************************************')
disp ('*****************************************************')
disp ('*****************************************************')
disp ('Example 12:  Nested split/join test ')
disp ('*****************************************************')
disp ('*****************************************************')
disp ('*****************************************************')

P0 = 0.1
P1 = 0.2
P2 = 0.3

% claculate probability for the two joiners to be the same as P1
disp 'Joiner Probabilities P3,P4 Should be:'
syms JoinProb
solve ( JoinProb + JoinProb* (1-JoinProb) - P1 , JoinProb )

t = 10
Pop = [1 0 0 0]*1000
```

```
Mat =  [1-P0 , P0 , 0 , 0 ; 0 , 1-P1, P1, 0 ; 0, 0, 1-P2, P2; 0, 0, 0,
1]

Result = Pop*(Mat^t)


% Example 12:  Nested split/join test
% This example is simulated as a simpler chain of 4 stages similar to
% example 6
disp ('Example 12:  Nested split/join test ')

MaxTime = 10

P0 = 0.1
P1 = 0.2
P2 = 1 - sqrt(7/10)   %0.3
P3 = 1 - 2/5*sqrt(5)  % 0.2
P4 = P3
P5 = P2

% Combined probabilities of transfer
P34 = P3+(1-P3)*P4
P25 = P2+(1-P2)*P5
P134 = P1*P34

% The following mapping of states occurs:
% A = 0
% B = 1,3,4
% C = 2,3,4
% D = 1,5
% E = 2,5
% F = 6

% Define the mapping Matrix from A-F to 0-6
%            A B C D E F
Mapping = [ 1 0 0 0 0 0   %0
            0 1 0 1 0 0   %1
            0 0 1 0 1 0   %2
            0 1 1 0 0 0   %3
            0 1 1 0 0 0   %4
            0 0 0 1 1 0   %5
            0 0 0 0 0 1 ] %6

Pop = [1 1 0 0 0 0]*500

%        A              B                C              D          E    F
Mat=[1-P0            P0                0              0          0    0
%A
        0  1-P1-P34+P134      P1*(1-P34)    P34*(1-P1)       P134    0
%B
        0              0  1-P2-P34+P2*P34             0  P34*(1-P2)   P2
%C
        0              0                0  1-P1-P5+P1*P5  P1*(1-P5)   P5
%D
```

```
        0             0               0             0      1-P25   P25
%E
        0             0               0             0          0     1
]%F


MultMat = Mat ^ MaxTime
DetailedResult = Pop*(MultMat)

% Convert the detailed result back to the mapped result
Result = DetailedResult * Mapping'

Res = Result ([1,2,3,7])

% Example 13:  Split and join test without termination in a subprocess
% This example is similar to example 12 when there is no transition
from
% one sub-process
disp ('*****************************************************')
disp ('*****************************************************')
disp ('*****************************************************')
disp ('Example 13:  Nested split/join test ')
disp ('*****************************************************')
disp ('*****************************************************')
disp ('*****************************************************')

MaxTime = 10

P0 = 0.1
P1 = 0.2
P2 = 0.3
P3 = 1 - 2/5*sqrt(5)  % 0.2
P4 = P3
P5 = 0

% Combined probabilities of transfer
P34 = P3+(1-P3)*P4
P25 = P2+(1-P2)*P5
P134 = P1*P34

% The following mapping of states occurs:
% A = 0
% B = 1,3,4
% C = 2,3,4
% D = 1,5
% E = 2,5
% F = 6

% Define the mapping Matrix from A-F to 0-6
%            A B C D E F
Mapping = [ 1 0 0 0 0 0   %0
            0 1 0 1 0 0   %1
            0 0 1 0 1 0   %2
            0 1 1 0 0 0   %3
            0 1 1 0 0 0   %4
```

```
            0  0  0  1  1  0    %5
            0  0  0  0  0  1 ]  %6

Pop = [1  1  0  0  0  0]*500

%       A              B                C              D          E    F
Mat=[1-P0             P0                0              0          0    0
%A
        0  1-P1-P34+P134      P1*(1-P34)     P34*(1-P1)       P134    0
%B
        0              0  1-P2-P34+P2*P34              0  P34*(1-P2)   P2
%C
        0              0                0  1-P1-P5+P1*P5  P1*(1-P5)   P5
%D
        0              0                0              0      1-P25  P25
%E
        0              0                0              0          0    1
]%F


MultMat = Mat ^ MaxTime
DetailedResult = Pop*(MultMat)

% Convert the detailed result back to the mapped result
Result = DetailedResult * Mapping'

Res = Result ([1,2,3,7])




% Example 15:  Simple Table Example:
disp ('*****************************************************')
disp ('*****************************************************')
disp ('*****************************************************')
disp ('Example 15:  Simple Table Example:')
disp ('*****************************************************')
disp ('*****************************************************')
disp ('*****************************************************')

Pop = [1 0]*100
t = 3
Outcome = [0 0];
P0=0;
IndividualResult = [];
for Gender = 1:2,
    for AgeGroup = 1:3,
        P0 = P0 + 0.1
        Mat =  [1-P0 , P0; 0 , 1]
        ResultAdd = Pop*(Mat^t)
        IndividualResult(:,Gender,AgeGroup) = ResultAdd;
    end
end
Outcome = sum(sum(IndividualResult,3),2)
OutcomeGender1 = sum(IndividualResult(:,1,:),3)
```

```
OutcomeAgeGroup1 = sum(IndividualResult(:,:,1),2)
OutcomeAgeGroup2 = sum(IndividualResult(:,:,2,:),2)


% Example 18: Tests Cost/QoL Wizard
disp ('*****************************************************')
disp ('*****************************************************')
disp ('*****************************************************')
disp ('Example 4: Tests Cost/QoL Wizard')
disp ('*****************************************************')
disp ('*****************************************************')
disp ('*****************************************************')

P0 = 1
P1 = 0.5
P2 = 0.5

t = 5
Pop = [1 0 0 0 ]*100

Mat =  [1-P0, P0 , 0 , 0; 0, 1-P1, P1 ,0  ; 0 , 0, P2, 1-P2; 0, 0, 0,
1]

Result = Pop*(Mat^t)
```

Results generated by running this code:

```
******************************************************
******************************************************
******************************************************
Example 1:  Simple Example:
******************************************************
******************************************************
******************************************************

P0 =

    0.0717


t =

     3


Pop =

   900   100


Mat =

    0.9283    0.0717
         0    1.0000


Result =

  719.9587  280.0413


OldDeadNum =

     0


AverageAgeAtDeath =

   31.2540
```

```
*****************************************************
*****************************************************
*****************************************************
Example 2:  Multiple Transitions in a Chain
*****************************************************
*****************************************************
*****************************************************

P0 =

    0.1000


P1 =

    0.2000


t =

     5


Pop =

   500   500     0


Mat =

    0.9000    0.1000         0
         0    0.8000    0.2000
         0         0    1.0000


Result =

  295.2450  295.2450  409.5100

*****************************************************
*****************************************************
*****************************************************
Example 3:  A fork state
*****************************************************
*****************************************************
*****************************************************
```

```
P0 =

    0.3000


P1 =

    0.6000


t =

     2


Pop =

   100     0     0


Mat =

    0.1000    0.3000    0.6000
         0    1.0000         0
         0         0    1.0000


Result =

    1.0000   33.0000   66.0000

*****************************************************
*****************************************************
*****************************************************
Example 4: Funny Loop Example
*****************************************************
*****************************************************
*****************************************************

P0 =

    0.1000


P1 =

    0.2000
```

```
P2 =

    0.3000


t =

     5


Pop =

   500   500   500


Mat =

    0.9000    0.1000         0
         0    0.8000    0.2000
    0.3000         0    0.7000


Result =

  791.1000  393.1950  315.7050

*****************************************************
*****************************************************
*****************************************************
Example 5a:  Multiple Transitions in a Chain with an
Expression and Boolean Covariate
*****************************************************
*****************************************************
*****************************************************

MaxTime =

     2


Pop =

        1000           0            0
```

```
MultMat =

     1     0     0
     0     1     0
     0     0     1


P0 =

    0.6703


P1 =

    0.6703


Mat =

    0.3297    0.6703         0
         0    0.3297    0.6703
         0         0    1.0000


MultMat =

    0.3297    0.6703         0
         0    0.3297    0.6703
         0         0    1.0000


P0 =

    0.6703


P1 =

    0.6703


Mat =

    0.3297    0.6703         0
         0    0.3297    0.6703
         0         0    1.0000
```

```
MultMat =

    0.1087    0.4420    0.4493
         0    0.1087    0.8913
         0         0    1.0000

Results for Gender = 0

Result =

  108.6889  441.9822  449.3290


Pop =

        1000           0           0


MultMat =

     1     0     0
     0     1     0
     0     0     1


P0 =

    0.4966


P1 =

    0.4066


Mat =

    0.5034    0.4966         0
         0    0.5934    0.4066
         0         0    1.0000


MultMat =

    0.5034    0.4966         0
         0    0.5934    0.4066
```

```
         0         0    1.0000


P0 =

    0.4966


P1 =

    0.4066


Mat =

    0.5034    0.4966         0
         0    0.5934    0.4066
         0         0    1.0000


MultMat =

    0.2534    0.5447    0.2019
         0    0.3522    0.6478
         0         0    1.0000

Results for Gender = 1

Result =

  253.4264  544.6771  201.8965

*****************************************************
*****************************************************
*****************************************************
Example 5b:  Multiple Transitions in a Chain with an
Expression and Continuous Covariate
*****************************************************
*****************************************************
*****************************************************

MaxTime =

     2


Ages =
```

```
    60    45


Age =

    60


Pop =

        1000            0            0


MultMat =

     1     0     0
     0     1     0
     0     0     1


Age =

    61


P0 =

    0.1541


P1 =

    0.0455


Mat =

    0.8459    0.1541         0
         0    0.9545    0.0455
         0         0    1.0000


MultMat =

    0.8459    0.1541         0
         0    0.9545    0.0455
```

```
         0         0    1.0000


Age =

    62


P0 =

    0.1496


P1 =

    0.0433


Mat =

    0.8504    0.1496         0
         0    0.9567    0.0433
         0         0    1.0000


MultMat =

    0.7194    0.2740    0.0067
         0    0.9132    0.0868
         0         0    1.0000

Results for Gender = 0

Result =

  719.3598  273.9693    6.6709


Age =

    45


Pop =

        1000            0            0
```

```
MultMat =

     1     0     0
     0     1     0
     0     0     1


Age =

    46


P0 =

    0.2417


P1 =

    0.0963


Mat =

    0.7583    0.2417         0
         0    0.9037    0.0963
         0         0    1.0000


MultMat =

    0.7583    0.2417         0
         0    0.9037    0.0963
         0         0    1.0000


Age =

    47


P0 =

    0.2346
```

```
P1 =

    0.0916


Mat =

    0.7654    0.2346         0
         0    0.9084    0.0916
         0         0    1.0000


MultMat =

    0.5804    0.3974    0.0221
         0    0.8209    0.1791
         0         0    1.0000

Results for Gender = 1

Result =

  580.4146  397.4372   22.1482

*****************************************************
*****************************************************
*****************************************************
Example 6:  Multiple Transitions in a Long Chain with an
Expression Containing a Continuous Covariate
*****************************************************
*****************************************************
*****************************************************

MaxTime =

     3


Ages =

    60    45


Age =

    60
```

```
Pop =

        1000            0            0            0


MultMat =

     1     0     0     0
     0     1     0     0
     0     0     1     0
     0     0     0     1


Age =

    61


P0 =

    0.1541


P1 =

    0.0455


P2 =

    0.0455


Mat =

    0.8459    0.1541         0         0
         0    0.9545    0.0455         0
         0         0    0.9545    0.0455
         0         0         0    1.0000


MultMat =

    0.8459    0.1541         0         0
         0    0.9545    0.0455         0
         0         0    0.9545    0.0455
```

```
         0         0         0    1.0000


Age =

    62


P0 =

    0.1496


P1 =

    0.0433


P2 =

    0.0433


Mat =

    0.8504    0.1496         0         0
         0    0.9567    0.0433         0
         0         0    0.9567    0.0433
         0         0         0    1.0000


MultMat =

    0.7194    0.2740    0.0067         0
         0    0.9132    0.0848    0.0020
         0         0    0.9132    0.0868
         0         0         0    1.0000


Age =

    63


P0 =

    0.1451
```

```
P1 =

    0.0412


P2 =

    0.0412


Mat =

    0.8549    0.1451         0         0
         0    0.9588    0.0412         0
         0         0    0.9588    0.0412
         0         0         0    1.0000


MultMat =

    0.6149    0.3671    0.0177    0.0003
         0    0.8756    0.1190    0.0055
         0         0    0.8756    0.1244
         0         0         0    1.0000

Results for Gender = 0

Result =

  614.9460  367.1033   17.6761    0.2747


Age =

    45


Pop =

        1000           0            0            0


MultMat =

     1     0     0     0
```

```
     0     1     0     0
     0     0     1     0
     0     0     0     1


Age =

    46


P0 =

    0.2417


P1 =

    0.0963


P2 =

    0.0963


Mat =

    0.7583    0.2417         0         0
         0    0.9037    0.0963         0
         0         0    0.9037    0.0963
         0         0         0    1.0000


MultMat =

    0.7583    0.2417         0         0
         0    0.9037    0.0963         0
         0         0    0.9037    0.0963
         0         0         0    1.0000


Age =

    47


P0 =
```

```
    0.2346


P1 =

    0.0916


P2 =

    0.0916


Mat =

    0.7654    0.2346         0         0
         0    0.9084    0.0916         0
         0         0    0.9084    0.0916
         0         0         0    1.0000


MultMat =

    0.5804    0.3974    0.0221         0
         0    0.8209    0.1703    0.0088
         0         0    0.8209    0.1791
         0         0         0    1.0000


Age =

    48


P0 =

    0.2276


P1 =

    0.0872


P2 =
```

```
    0.0872


Mat =

    0.7724    0.2276         0         0
         0    0.9128    0.0872         0
         0         0    0.9128    0.0872
         0         0         0    1.0000


MultMat =

    0.4483    0.4949    0.0549    0.0019
         0    0.7493    0.2270    0.0237
         0         0    0.7493    0.2507
         0         0         0    1.0000

Results for Gender = 1

Result =

  448.2904  494.9205   54.8587    1.9305

*****************************************************
*****************************************************
*****************************************************
Example 7: Funny Loop Example with an Expression -
(Extending the example from figure 2c in Isaman, 2006)
*****************************************************
*****************************************************
*****************************************************

MaxTime =

     3


Ages =

    60    45


Age =

    60
```

```
Pop =

        1000            0            0


MultMat =

     1     0     0
     0     1     0
     0     0     1


Age =

    61


P0 =

    0.2894


P1 =

    0.5326


P2 =

    0.5326


Mat =

    0.7106    0.2894         0
         0    0.4674    0.5326
    0.5326         0    0.4674


MultMat =

    0.7106    0.2894         0
         0    0.4674    0.5326
    0.5326         0    0.4674
```

```
Age =

    62


P0 =

    0.2837


P1 =

    0.5273


P2 =

    0.5273


Mat =

    0.7163    0.2837         0
         0    0.4727    0.5273
    0.5273         0    0.4727


MultMat =

    0.5090    0.3384    0.1526
    0.2808    0.2209    0.4982
    0.6280    0.1511    0.2209


Age =

    63


P0 =

    0.2780


P1 =

    0.5220
```

```
P2 =

    0.5220


Mat =

    0.7220    0.2780         0
         0    0.4780    0.5220
    0.5220         0    0.4780


MultMat =

    0.4472    0.3033    0.2496
    0.4628    0.1837    0.3535
    0.5687    0.2468    0.1845

Results for Gender = 0

Result =

  447.1718  303.2561  249.5721


Age =

    45


Pop =

        1000           0           0


MultMat =

     1     0     0
     0     1     0
     0     0     1


Age =

    46
```

```
P0 =

    0.3906


P1 =

    0.6188


P2 =

    0.6188


Mat =

    0.6094    0.3906         0
         0    0.3812    0.6188
    0.6188         0    0.3812


MultMat =

    0.6094    0.3906         0
         0    0.3812    0.6188
    0.6188         0    0.3812


Age =

    47


P0 =

    0.3829


P1 =

    0.6126


P2 =
```

```
    0.6126


Mat =

    0.6171    0.3829         0
         0    0.3874    0.6126
    0.6126         0    0.3874


MultMat =

    0.3760    0.3846    0.2393
    0.3791    0.1477    0.4732
    0.6154    0.2369    0.1477


Age =

    48


P0 =

    0.3753


P1 =

    0.6065


P2 =

    0.6065


Mat =

    0.6247    0.3753         0
         0    0.3935    0.6065
    0.6065         0    0.3935


MultMat =
```

```
    0.3801    0.2925    0.3275
    0.5238    0.2004    0.2758
    0.4740    0.3242    0.2018

Results for Gender = 1

Result =

  380.0611  292.4802  327.4586

*****************************************************
*****************************************************
*****************************************************
Example 9: Combined Fork Loop and Event state
*****************************************************
*****************************************************
*****************************************************

P0 =

    0.1000


P1 =

    0.8000


P2 =

    0.2000


P3 =

    0.1000


t =

    10


Pop =

   400   500   100
```

```
Mat =

    0.9000    0.0800    0.0200
         0    0.9800    0.0200
         0         0    1.0000


Result =

  139.4714  595.8942  264.6345

*****************************************************
*****************************************************
*****************************************************
Example 12:  Nested split/join test
*****************************************************
*****************************************************
*****************************************************

P0 =

    0.1000


P1 =

    0.2000


P2 =

    0.3000

Joiner Probabilities P3,P4 Should be:

ans =

 1-2/5*5^(1/2)
 1+2/5*5^(1/2)



t =

    10
```

```
Pop =

        1000           0           0           0


Mat =

    0.9000    0.1000         0         0
         0    0.8000    0.2000         0
         0         0    0.7000    0.3000
         0         0         0    1.0000


Result =

  348.6784  241.3043  162.1776  247.8397
```

Example 12: Nested split/join test

```
MaxTime =

    10


P0 =

    0.1000


P1 =

    0.2000


P2 =

    0.1633


P3 =

    0.1056


P4 =
```

```
    0.1056


P5 =

    0.1633


P34 =

    0.2000


P25 =

    0.3000


P134 =

    0.0400


Mapping =

     1     0     0     0     0     0
     0     1     0     1     0     0
     0     0     1     0     1     0
     0     1     1     0     0     0
     0     1     1     0     0     0
     0     0     0     1     1     0
     0     0     0     0     0     1


Pop =

   500   500     0     0     0     0


Mat =

    0.9000    0.1000         0         0         0
0
         0    0.6400    0.1600    0.1600    0.0400
0
         0         0    0.6693         0    0.1673
0.1633
```

```
         0         0         0    0.6693    0.1673
0.1633
         0         0         0         0    0.7000
0.3000
         0         0         0         0         0
1.0000


MultMat =

    0.3487    0.1297    0.0745    0.0745    0.0958
0.2768
         0    0.0115    0.0356    0.0356    0.1096
0.8077
         0         0    0.0180         0    0.0557
0.9263
         0         0         0    0.0180    0.0557
0.9263
         0         0         0         0    0.0282
0.9718
         0         0         0         0         0
1.0000


DetailedResult =

  174.3392   70.6010   55.0427   55.0427  102.7357
542.2386


Result =

  174.3392  125.6437  157.7785  125.6437  125.6437
157.7785  542.2386


Res =

  174.3392  125.6437  157.7785  542.2386

*****************************************************
*****************************************************
*****************************************************
Example 13:  Nested split/join test
*****************************************************
*****************************************************
*****************************************************
```

```
MaxTime =

    10


P0 =

    0.1000


P1 =

    0.2000


P2 =

    0.3000


P3 =

    0.1056


P4 =

    0.1056


P5 =

     0


P34 =

    0.2000


P25 =

    0.3000


P134 =
```

```
    0.0400


Mapping =

     1     0     0     0     0     0
     0     1     0     1     0     0
     0     0     1     0     1     0
     0     1     1     0     0     0
     0     1     1     0     0     0
     0     0     0     1     1     0
     0     0     0     0     0     1


Pop =

   500   500     0     0     0     0


Mat =

    0.9000    0.1000         0         0         0
0
         0    0.6400    0.1600    0.1600    0.0400
0
         0         0    0.5600         0    0.1400
0.3000
         0         0         0    0.8000    0.2000
0
         0         0         0         0    0.7000
0.3000
         0         0         0         0         0
1.0000


MultMat =

    0.3487    0.1297    0.0560    0.1116    0.1062
0.2478
         0    0.0115    0.0170    0.0958    0.1413
0.7344
         0         0    0.0030         0    0.0252
0.9718
         0         0         0    0.1074    0.1583
0.7344
```

```
         0         0         0         0    0.0282
0.9718
         0         0         0         0         0
1.0000


DetailedResult =

  174.3392   70.6010   36.5085  103.7382  123.7069
491.1061


Result =

  174.3392  174.3392  160.2155  107.1095  107.1095
227.4451  491.1061


Res =

  174.3392  174.3392  160.2155  491.1061

*****************************************************
*****************************************************
*****************************************************
Example 15:  Simple Table Example:
*****************************************************
*****************************************************
*****************************************************

Pop =

   100     0


t =

     3


P0 =

    0.1000


Mat =
```

```
    0.9000    0.1000
         0    1.0000


ResultAdd =

   72.9000   27.1000


P0 =

    0.2000


Mat =

    0.8000    0.2000
         0    1.0000


ResultAdd =

   51.2000   48.8000


P0 =

    0.3000


Mat =

    0.7000    0.3000
         0    1.0000


ResultAdd =

   34.3000   65.7000


P0 =

    0.4000


Mat =
```

```
    0.6000    0.4000
         0    1.0000


ResultAdd =

   21.6000   78.4000


P0 =

    0.5000


Mat =

    0.5000    0.5000
         0    1.0000


ResultAdd =

   12.5000   87.5000


P0 =

    0.6000


Mat =

    0.4000    0.6000
         0    1.0000


ResultAdd =

    6.4000   93.6000


Outcome =

  198.9000
  401.1000
```

```
OutcomeGender1 =

  158.4000
  141.6000


OutcomeAgeGroup1 =

   94.5000
  105.5000


OutcomeAgeGroup2 =

   63.7000
  136.3000

*****************************************************
*****************************************************
*****************************************************
Example 4: Tests Cost/QoL Wizard
*****************************************************
*****************************************************
*****************************************************

P0 =

     1


P1 =

    0.5000


P2 =

    0.5000


t =

     5


Pop =
```

```
   100     0     0     0


Mat =

         0    1.0000         0         0
         0    0.5000    0.5000         0
         0         0    0.5000    0.5000
         0         0         0    1.0000


Result =

         0    6.2500   25.0000   68.7500
```