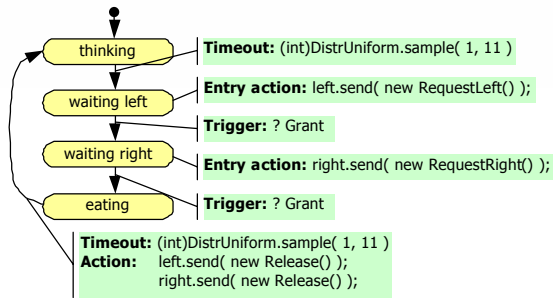




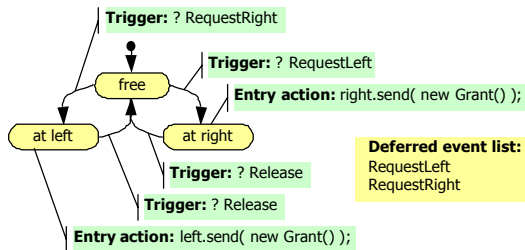
C10 Dining Philosophers II – AnyLogic

Simulator: AnyLogic (www.xjtek.com) is a general-purpose simulation environment for discrete, continuous and hybrid systems. It employs UML-RT structure diagrams for building hierarchical models in object-oriented way and *hybrid statecharts* for behaviour specification. The generated model is Java and can be extended with user's Java code.

Model: Implementation of the Dining Philosophers model in AnyLogic is very straightforward. There are three classes: Philosopher, Chopstick, and Table. The behaviour of Philosopher and Chopstick classes is naturally specified using statechart notation.



The chopstick statechart reacts on *RequestLeft* and *RequestRight* events and accordingly changes its state.



AnyLogic event scheduler handles simultaneous access situation (that is in fact several possible events to process) by randomly choosing one of the accessing entities. The current version of the tool does not provide possibility to assign priority to an event. However, it is possible to introduce such behaviour to the model by adding necessary code.

Task a Single Run – Utilisation Results

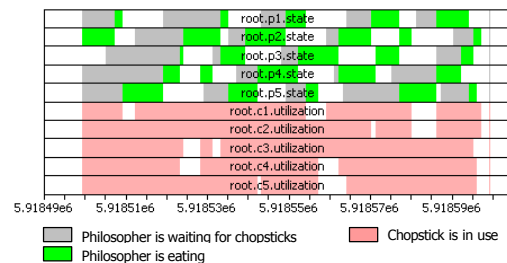
The model simulation gave chopsticks utilization rates shown in the table at the right.

	Utilisation
chopstick1	0.917475
chopstick2	0.917677
chopstick3	0.917570
chopstick4	0.917581
chopstick5	0.917363
total	0.914047

Next figure shows statistics of actions time per philosopher and the times for all philosophers together:

	Thinking		waiting		eating	
	mean	std.dev.	mean	std.dev.	mean	std.dev.
p1	5.50670	2.86941	11.1472	8.05305	5.49178	2.87256
p2	5.49037	2.87052	11.1613	8.05765	5.49531	2.86972
p3	5.50107	2.87375	11.1572	8.05010	5.49741	2.87052
p4	5.49901	2.87126	11.1531	8.05759	5.49176	2.86981
p5	5.50032	2.87147	11.1493	8.07832	5.48537	2.87022
O	5.49804	2.87100	11.1536	8.05934	5.49377	2.87085

The following Gantt chart illustrates state changes of philosopher and chopstick statecharts over time:



The thin grey line at the right of the chart represents a situation when all philosophers stop thinking and have taken their left chopsticks, causing the deadlock. AnyLogic tool provides automatic deadlock detection and immediately stops the simulation run.

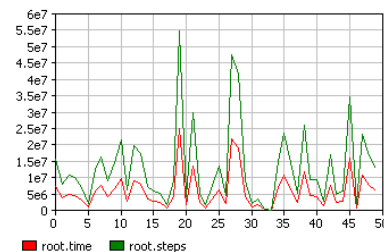
Task b Multiple runs – deadlock observation:

This task collects statistics of mean model execution time and number of steps taken before the deadlock situation happen (results for of 50 runs in table below).

Time Till Deadlock			
Count	50	Min	28413.0
Mean	5927127.52	Max	2.5074141E7
Deviation	5461891.91	Variance	2.9832263E13

Steps Till Deadlock			
Count	50	Min	62496.0
Mean	1.296137E7	Max	5.4855794E7
Deviation	1.194404E7	Variance	1.4266019E14

The following diagram shows simulation time and performed model steps distribution per simulations.



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