

Simulation of Queuing Systems using QS_PN_Simulation Tool

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The paper deals with a new tool for discrete system simulation called QS_PN_Simulation. This tool allows easy creating of queuing system models as Petri net graphs. Simulation experiments with models can be done and chosen statistic results of simulations can be obtained. The use of this system is demonstrated in the paper: creation of a model of chemical production system, simulation experiments with this model and obtained results are presented here. Supposed extension of proposed tool is then discussed in the conclusion of the paper.

Introduction

This paper deals with one part of a simulation tool that is developing in our department for hybrid/combined (discrete and continuous) simulations. Proposed part of this tool is focused on the discrete simulation only and it allows easy creating of queuing system (QS) models as Petri net (PN) graphs – that is why it was named QS_PN_Simulation tool.

The main idea for QS_PN_Simulation tool design was fact that design using mathematical equations or the other text form is not user friendly. For users a visual design is more appropriate and friendly. Therefore the Petri net was chosen as a main tool for model representation and graphical environment for model building were proposed and implemented. All system has been written in the Java language and it allows a building of the model as Petri net graph, simulation experiments with this model with given parameters and obtained results evaluation.

It can be mentioned proposed QN_PS_Simulation tool has been primarily designed for discrete simulation, but it can be used as a tool for demonstration of Petri net behavior, too.

1 QS_PN_Simulation tool

As was mentioned above the QS-PN-Simulation tool is a new tool for modeling and simulations of discrete systems, it has been implemented in the Java language and it has a user friendly graphical user interface that allows easy creating queuing system models as Petri net graphs.

As is well known Petri net is a discrete mathematic model that allows description of control flows and information dependences inside the modeled system. Modeling of parallelism and manual exclusion is its main positive.

Each model in QS-PN-Simulation tool uses places and transitions as follows:

- *Normal place*: standard place without any special purpose.
- *Queue*: place with requests waiting for service (standard queue).
- *Store*: place with limited capacity.
- *Facility*: place with capacity equal to one.
- *Timed transitions*: there are two types of these transitions: transitions with constant waiting time and transitions with randomly generated waiting time.
- *Immediate transitions*: they always have higher priority than timed transitions. These transitions can be associated with priority or with probability. So, there are three types of immediate transitions:
 - normal immediate transitions,
 - immediate transitions with priority,
 - immediate transitions with probability.

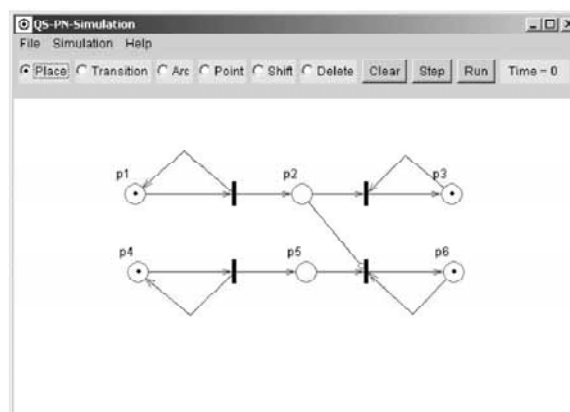


Figure 1. Simple model (main window) in QN_PN_Simulation tool.

Example of simple model (main window) in the QN_PS_Simulation tool is shown in Figure 1, examples of dialog windows for parameters settings are shown in Figure 2.

2 Production system

The (elements of the) system can be in one of four stages:

1. *Filling*: there are four solvents in four tanks that are used to filling reactor. Reactor is filled with solvents in successive steps and time of each filling is 30 minutes. Filling time of tanks are insignificant with respect to time of reaction – that means, that all tanks are full before next filling state.
2. *Reaction*: the reaction begins immediately after the last solvent is poured into reactor, time of reaction is 1080 minutes. After this time, liquid is poured out from the reactor to the stirring tank. Time of discharge of reactor is 60 minutes. When the reactor is empty, it returns to its filling stage immediately.
3. *Stirring*: the process of stirring is done in stirring tank and it takes 360 minutes. Stirrer has breakdown with 3% probability in whichever stage of production process. Time of stirrer repair is 30 - 50 minutes uniformly.
4. *Testing and pouring*: test (60 minutes) follows after stirring and liquid must be stirring again with 10% probability. If the test is successful, liquid is poured out from stirring tank to the storage container. This takes 120 minutes.

Storage container is then put into store. Maximal capacity of store is 20 containers. There is a loader, that immediate loads the container on the deck of cars. Maximal capacity of each car is 3 containers and time of loading is 5 -7 minutes (uniformly). If a car is full, it leaves away. Car goes back to the factory during three till four days.

2.1 Simulation and results

Model of above described production system in QN_PS_Simulation tool (the main window) is shown in Figure 4. The meanings of symbols used are:

- S1, ..., S4: Solvents 1,..., 4
- P1, P2 Start and end of reactor filling

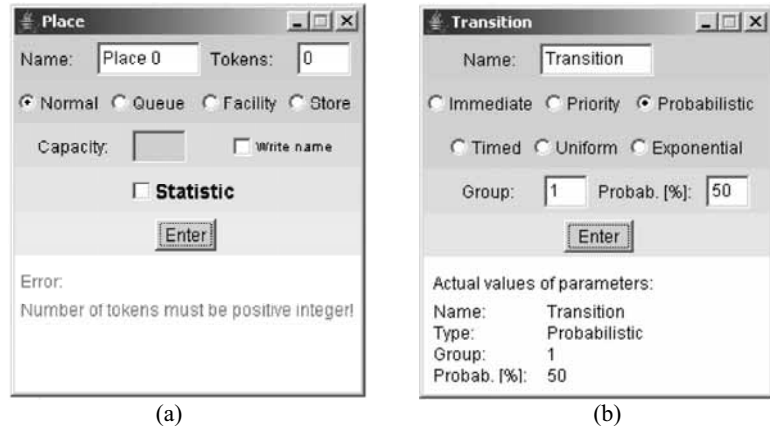


Figure 2. Dialog windows for parameter settings of (a) place, (b) transition.

- P3 Subnet for filling
- P4, P5 Start and end of reaction
- P6 Subnet for stirring, testing and breakdown
- P7, P14 Start and end of subnet P6
- P8, P9 Start and end of stirring
- P10 Breakdown of stirrer
- P11 Test
- P12 Test failed
- P13 Test was successful
- P14 Liquid is in storage container
- P15 Subnet for loading/transport of containers
- P16 Start of subnet P15, container is in the store
- P17 Car waiting (loading of containers)
- P18 Number of containers on the car deck
- P19 Container on the deck
- P20 Car is ready for departure

The main aim of experiment with the model of chemical production system was a simulation its activity during one year and acquisition new knowledge about real system: number of produced containers, number of stirring tank repairs, number of unus-

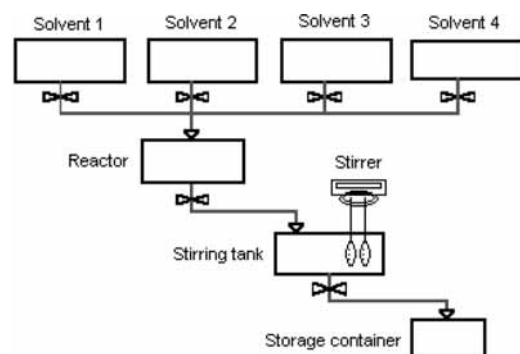


Figure 3. Chemical production system.

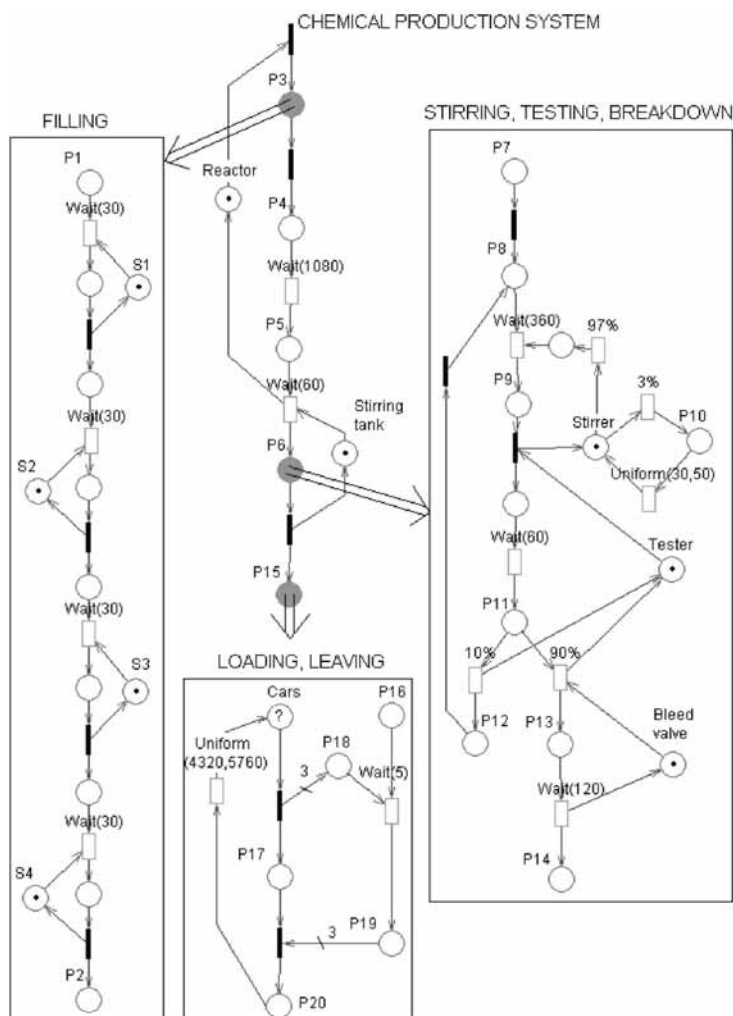


Figure 4. Model of chemical production system in QN_PS simulation tool main window.

successful stirrings, utilization of individual facilities, optimal number of cars for distribution of chemical liquid, etc. On the basis of simulation results, optimal resolution for acceleration of production could be found.

Obtained simulation results for one year of produce were as follows:

- System produced 415 containers with liquid.
- Stirrer was breakdown two times.
- Number of unsuccessful stirrings was 49.
- Utilization of facilities: reactor: 100 %, stirring tank: 51 %, tester: 5,3 %, bleed valves: 9,5 %.
- Maximal two containers were in store
- Optimal number of cars is two.

If a new reactor was added the results changed:

- System produced 774 containers with liquid.
- Stirrer was breakdown thirty-two times.
- Number of unsuccessful stirrings was 96.
- Utilization of facilities: reactor: 100 %, stirring tank: 100 %, tester: 10 %, bleed valves: 18 %.
- Store was overload for two cars (160 containers), the three containers were stored for three cars.
- Optimal number of cars is three.

3 Conclusion

QS-PN-Simulation tool has been tested in several theoretical and practical examples. Results obtained have been compared with those obtained by SIM-LIB/C++ that is classical simulation tool. We can state, that correspondence of both results have been very good and that QN_PS_Simulation tool is applicable and usable in practice. Its main advantage is user friendly GUI and we believe that it will be useful for other users, too.

Our next work will be focused on extension of QS-PN-Simulation with analog elements as are integrators, invertors, multipliers etc. Kernel of our

tool is designed with aspect of that extension and the only graphical visualization of results has not been solved yet.

References

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