MOSEL - Modeling, Specification and Evaluation Language

Jörg Barner, Khalid Begain, Björn Beutel,
Gunter Bolch and Helmut Herold

University Erlangen, 2003

MOSEL

Outline

- Motivation
- MOSEL
  - Structure of the MOSEL Modelling Environment
  - Constructs of MOSEL
- Production Line Examples
  - Fundamental Systems: Basic Model, Multiple Machines, Finite Buffer, Batch Processing, Unreliable Machines
  - Preemption in a Multitasking environment
- Other Real Life Examples
- IGL Intermediate Graphic Language
- Related Work and Future Work

MOSEL

Motivation (1)

- Discrete Event Systems :
  - Dynamic evolution of the system proceeds from one **discrete** state to another at arbitrary moments **i**n time.
  - State changes (Transitions) are triggered by **Events**
- Two different **modelling paradigms** for **DES** are popular
  - **Process-Activity** based modelling
  - **State-Transition** based modelling
- MOSEL can be used for Performance and Reliability Evaluation of DES
- MOSEL follows the state-transition based modelling paradigm!

Motivation (2)

- Performance and Reliability Evaluation Methods
  - Analytical Methods:
    Very fast, but restrictive
  - Simulation:
    Very time consuming, but universal
  - Numerical Methods:
    Faster than Simulation, but not applicable in many situations
  - Measurement:
    Expensive, only for already existing sytems; time consuming
- Performance and Reliability Evaluation with MOSEL employs numerical and simulative Evaluation Methods
- Based on a total or partial generation of the state-space of the DES

Motivation (3)

- State-Space based Performance and Reliability Evaluation
  - **Create a Model** of the DES using a (Formal) Description Technique containing
    - Specification of **structure** and **dynamic behaviour** of the DES
    - Specification of the **performance measures** of interest
    - Course of time can be modelled **stochastically** (continuous random variables are associated with the state changes of the DES)
  - Use a **tool** supporting the chosen modelling formalism for evaluation:
    - automatically generates a **state-space**-level dynamic model
    - maps onto a **stochastic process** or a **Discrete Event Simulation** model.
    - calculates **state probabilities** numerically or by simulation
    - derives the **performance measures** as specified in the high-level description from the state probabilities

Motivation (4)

- Performance and Reliability Evaluation Modelling Formalisms
  - Queueing Network Models
  - Petri Net Models
  - Precedence Graph Models
  - Fault Trees
  - Markov Models
  - Stochastic Activity Networks
  - Stochastic Process Algebras

Motivation (5)

- Tools for Performance and Reliability Evaluation
  - Queueing Network Tools

    QNAP, RESQ, PEPSY, ...
  - Petri Net Tools

    SPNP, TimeNET, PETSI, GreatSPN, ...
  - Tools based on Stochastic Process Algebras

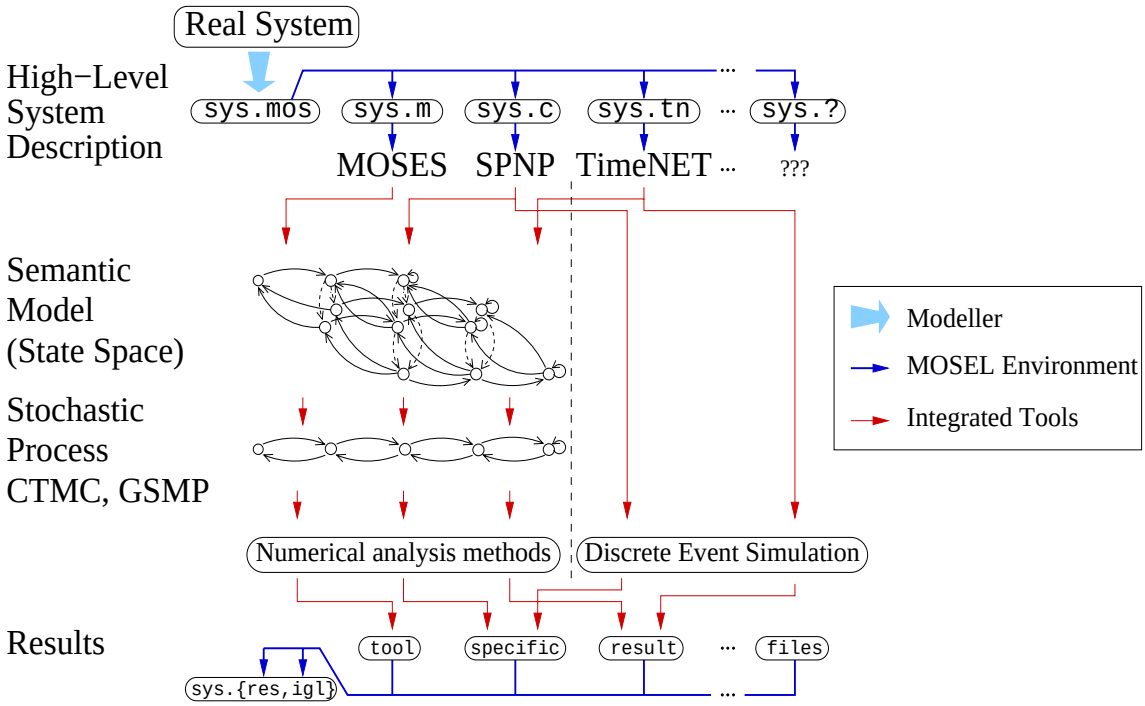
    EMPA, PEPA, TIPP, ...

Motivation (6)

- **Observations**:
  - Learning more than one modeling language is very time consuming
  - Many tools for performance evaluation with well-tested solution methods already exist
  - Graphical modelling formalisms are sometimes confusing for larger systems with complex synchronisation schemes
- Conclusion:
  - Provide the performance modeller with an easy-to-learn, texutal modelling language in which he can describe the relevant system properties directly
  - Don't re-invent the wheel concerning the solution methods, reuse the power of existing performance and reliability tools

☞ **MOSEL**: **MO**deling, **S**pecification and **E**valuation **L**anguage

Performance Modelling with the MOSEL-environment



MOSEL MOdeling Specification and Evaluation Language

- **SPNP 6.1** - Stochastic Petri Net Package (Duke University)
- New in Version 6.1: Support for the analysis of Non-Markovian Petri Nets via Discrete Event Simulation
- Generation and Solution of CTMCs and GSMCs
  - Input: Description of the System in CSPL (C based Petri Net Language)
    - Generated automatically from the MOSEL Description of the System by the MOSEL-CSPL translation component
  - Output: State Probabilities, reward based measures
  - Solution Methods
    - Numerical Solution of CTMCs (steady state and transient)
    - Discrete Event Simulation of CTMCs and GSMCs (steady state and transient)

MOSEL MOdeling Specification and Evaluation Language

- **TimeNET 3.0** - Timed Net Evaluation Tool
  (Technical University Berlin)
- Support for different Types of extended Petri Net Classes
  - eDSPN: extended Deterministic and Stochastic Petri Nets
- Generation and Solution of the Markov Chain
  - Input: Description of the System in proprietary `.TN`-format
    - Generated automatically from the MOSEL Description of the System by the MOSEL-`.TN` translation component.
  - Output: State Probabilities, Reward based measures
    Solution Methods
    - Various Numerical Solution Algorithms, Discrete Event Simulation

MOSEL MOdeling Specification and Evaluation Language

MOSEL MOdeling Specification and Evaluation Language

- Structure of a MOSEL file (1)

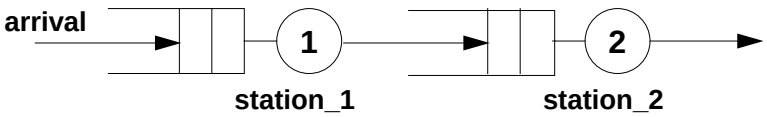
  - **Parameter declaration part**
    - System parameter sets
    - Constants
  - **Component definition part (node part)**
    - Components of the system (called `NODE`s), each `NODE` can hold an integer number of jobs or token
    - Range of the local state spaces (each `NODE` has a fixed capacity)
    - Initial number of token in each node (= the global system start state)
    - Specification of prohibited system states (optional)

MOSEL MOdeling Specification and Evaluation Language

- Structure of a MOSEL file (2)
  - **Transition definition part (rules part):** Specification of the transitions (called rules) which determine the dynamic behaviour of the system
    - Condition part (specify the circumstances under which the rule can be "executed", complex synchronisation schemes are possible)
    - Action part (stochastic timing, branching probabilities, priorities, reenabling policies)
  - **Results part:** Specification of the performance measures (state probabilities, mean response times, MTTF, reward-based measures, etc.)
  - **Picture part:** Specification of the graphical representation of the results

MOSEL - Queueing Network Examples

- Open Tandem Network (1)

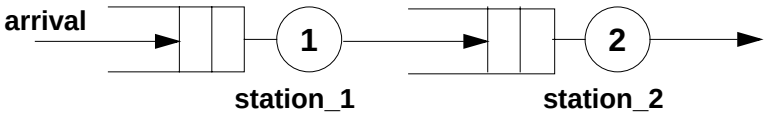


- **Description in MOSEL**

```
/* Definition of the system parameters */
CONST arrival := 0.25;
CONST ServiceRate_1 := 0.28;
CONST ServiceRate_2 := 0.22;
```

MOSEL - Queueing Network Examples

- Open Tandem Network (2)

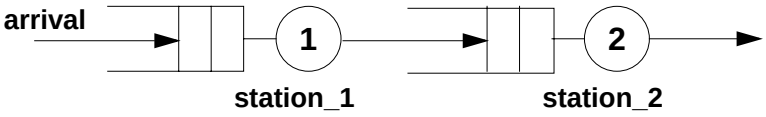



```
/* Definition of the system components */
    NODE   station_1 [K]      := 0;
    NODE   station_2 [K]      := 0;
    NODE   num [K]            := 0;

/* Definition of the arrival of jobs */
    FROM EXTERN   TO   station_1, num   RATE   arrival;
```


MOSEL - Queueing Network Examples

MOSEL - Queueing Network Examples

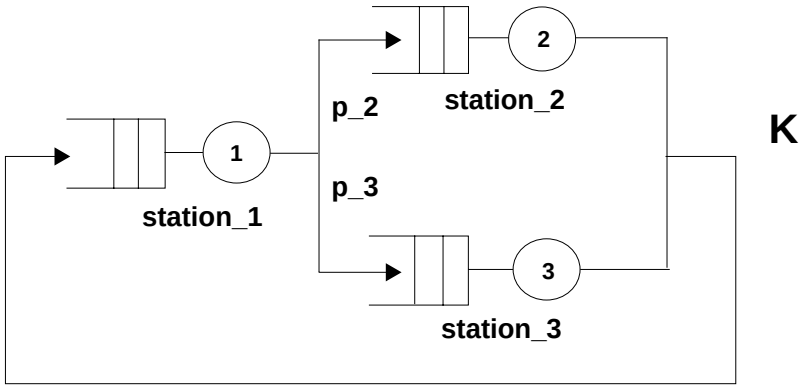
- Open Tandem Network (3)




```
/* Definition of the behavior of the stations */
FROM   station_1   TO   station_2   RATE   ServiceRate_1;
FROM   station_2, num   TO EXTERN   RATE   ServiceRate_2;

/* Definition of the performance measures */
PRINT   rho1  :=  PROB  (station_1 > 0);
PRINT   WIP :=  MEAN  (num);
PRINT   system_time := WIP / arrival;
```

MOSEL - Queueing Network Examples

- Closed Queueing Network



/* Definition of the system components */

NODE station_1 **[**K**]** **:=** K;
NODE station_2 **[**K**]** **:=** 0**;**
NODE station_3 **[**K**]** **:=** 0;
ASSERT station_1 + station_2 + station_3 **=** K; (<=K)

MOSEL - Queueing Network Examples

- Closed Queueing Network (2)

/* Definition of the behavior of the stations */

FROM station_1 **RATE** ServiceRate_1
THEN **{** **TO** station_2 **WEIGHT** p_2;
TO station_3 **WEIGHT** p_3**;}**
FROM station_2 **TO** station_1 **RATE** ServiceRate_2**;**
FROM station_3 **TO** station_1 **RATE** ServiceRate_3**;**

/* Specification of the performance measures */

PRINT utilization_1 **:= UTIL(**station_1**);**
PRINT throughput_1 **:=** utilization_1 ***** ServiceRate_1**;**

MOSEL - Queueing Network Examples

- A bridged MOSEL Version using "loops"

```
/* Definition of the system components */

 NODE   station_1 [K]   := K;
@<2,3> { NODE   station_# [K]  :=  0; }

ASSERT   station_1 + station_2 + station_3  =  K;

/* Definition of the behavior of the stations */

FROM  station_1  RATE   ServiceRate_1
THEN  {  TO  station_2  WEIGHT  p_2;
         TO  station_3  WEIGHT  p_3;}
@<2,3> { FROM  station_#  TO  station_1   RATE  ServiceRate_#;}
```

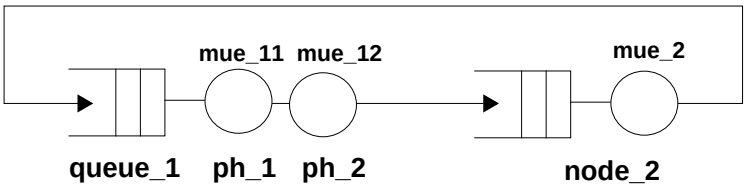

MOSEL - Queueing Network Examples

- A bridged MOSEL Version using "loops" (2)

```
/* Specification of the performance measures */

@<1,2,3>{ PRINT utilization_#  = UTIL(station_#); }
@<1,2,3>{ PRINT throughput_#  =  utilization_# * ServiceRate_#; }
```

MOSEL - Queueing Network Examples

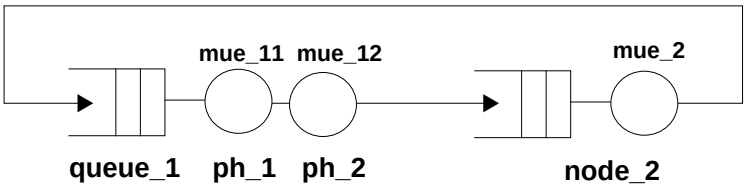
- Non-Productform Queueing Network




```
/* Definition of the state vector */
NODE   queue_1 [K]     := K;
NODE   phase_1 [1]     := 0;
NODE   phase_2 [1]     := 0;
NODE   node_2 [K]      := 0;

ASSERT queue_1 + phase_1 + phase_2 + node_2  = K;
```

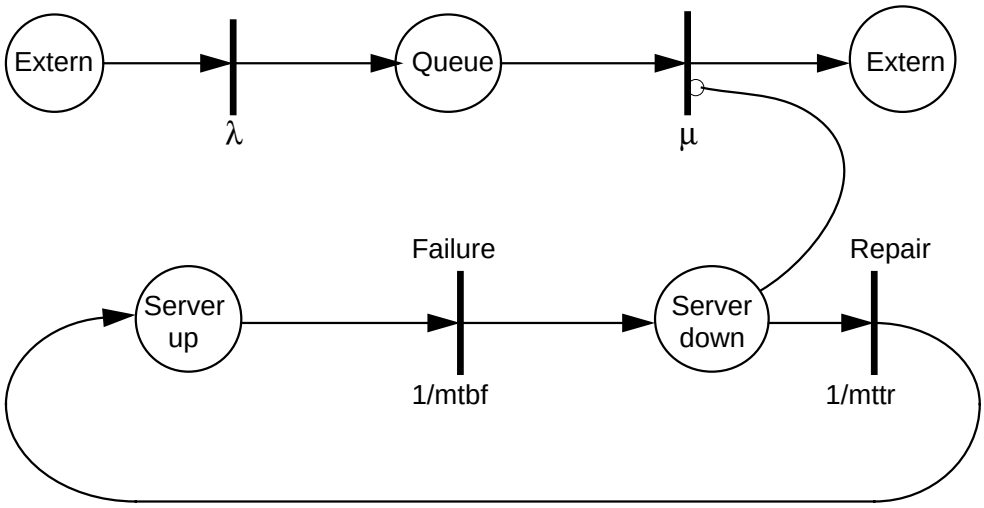

MOSEL - Queueing Network Examples

- Nonproductform Queueing Network (2)




```
/* Behavior of node_1 */
IF  (phase_1 + phase_2 = 0) FROM   queue_1   TO  phase_1;
FROM   phase_1   TO  phase_2   RATE   mue_11;
FROM   phase_2   TO  node_2    RATE  mue_12;

/* Behavior of node_2 */
FROM   node_2   TO   queue_1   RATE   mue_2;
```

Petri Net Example



Single Server with failure and repair

Petri Net Example (2)

MOSEL Specification:

```
/*--------------------------------- Constants and Parameter sets-------*/

CONST K := 10;
CONST mtbf := 10000;
CONST mttr  := 10;
PARAMETER lambda := 0.1, 0.2, 0.3, 0.4, 0.5, 0.6 0.8, 1;
PARAMETER mue := 0.5, 0.8, 1, 1.5, 1.8, 2, 3;
ENUM cpu_state := { down, up };

/*---------------------------------------- Node definitions -------*/

NODE queue[K]       := 0 ;
NODE server[cpu_state] := up;

/*--------------------------- Arrival and service of the jobs -------*/

FROM EXTERN   TO queue RATE lambda;
IF (server = up) FROM queue  TO EXTERN  RATE mue   ;
```

Petri Net Example (3)

MOSEL Specification

```
/*----------------------------- Repair/Failure of the server -------*/

FROM server[up]    TO server[down]  RATE 1/mtbf;
FROM server[down]  TO server[up] RATE 1/mttr;

/*------------------------------------------------ Results -------*/

PRINT server_idle := PROB (queue == 0) ;
PRINT server_reject := PROB (queue == K) ;
PRINT rate_reject := lambda *server_reject;
PRINT mean_qlength   := MEAN (queue) ;
PRINT util_server := UTIL (queue) ;
PRINT throughput := util_server*mue ;

/*------------------------------------------------ Pictures -------*/

PICTURE "Mean queue length"
   PARAMETER lambda
   CURVE  mean_qlength ;
```

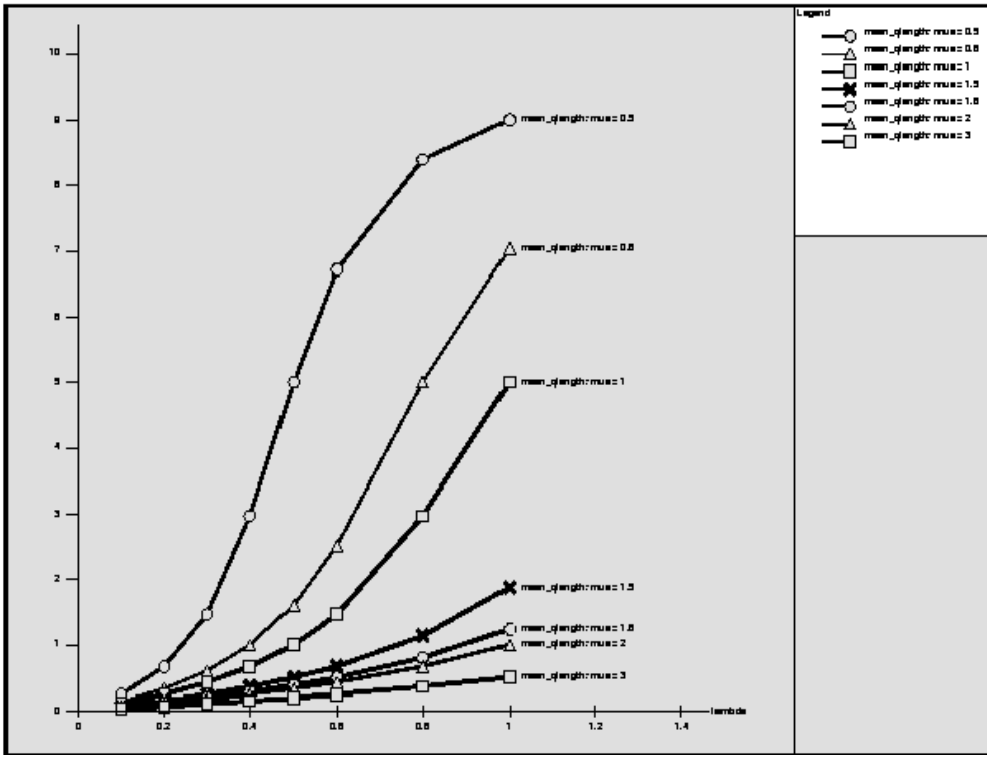

Petri Net Example (4)

Invoking the MOSEL-ENVIRONMENT:

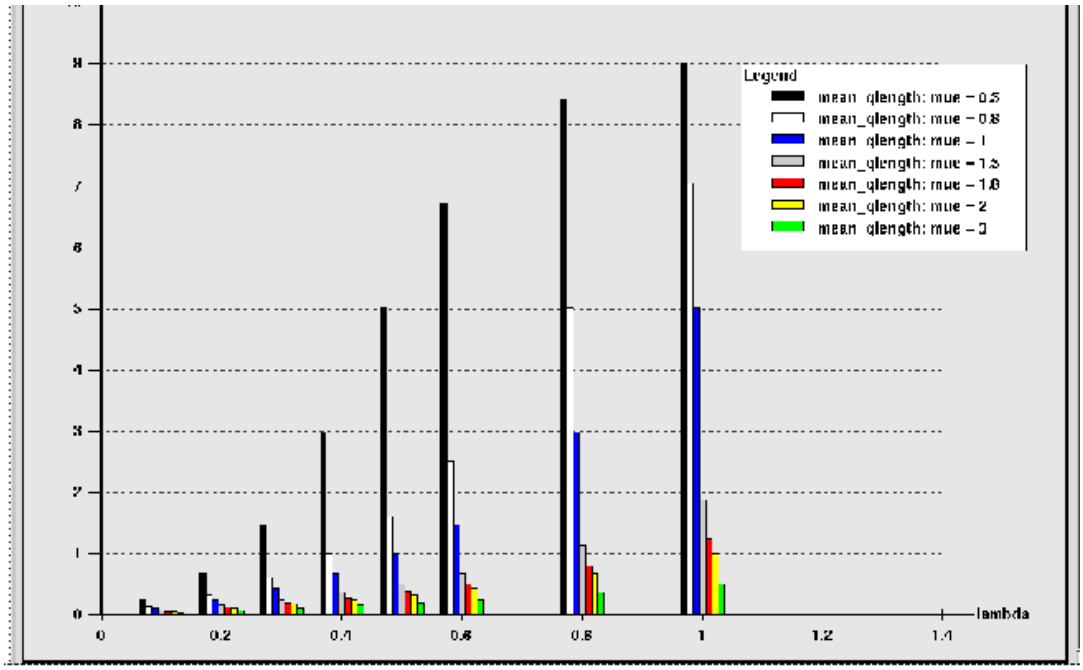
mosel2 -cs petri.msl --> petri.res --> petri.igl
igl petri.igl --> pictures

Results:

```
..... lambda = 0.1, mue = 0.5 .....
   server_idle = 0.665874058769
   server_reject = 1.82017918692e-06
   rate_reject = 1.82017918692e-07
   mean_qlength = 0.251555031241
   util_server = 0.20059915656

..... lambda = 0.1, mue = 0.8 .....
  server_idle = 0.874438162634
  server_reject = 1.33052923469e-06
  rate_reject =   .....
   .
   .

..... lambda = 1, mue = 2 .....
   server_idle = 0.499527144294
   server_reject = 0.000962398971526
   rate_reject = 0.000962398971526
   mean_qlength = 1.00283434233
   thruput = 1.00094571141

..... lambda = 1, mue = 3 .....
   server_idle = 0.665874058769
   server_reject = 1.82017918692e-06
   rate_reject =  .....
```

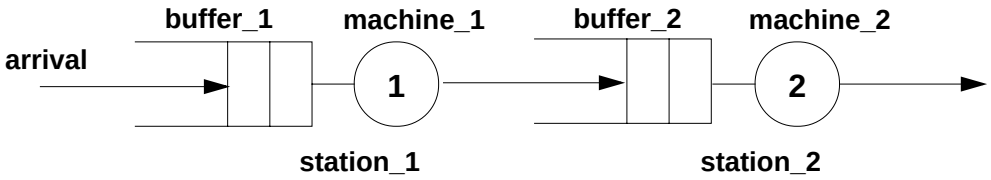


Petri Net Example (4)



Production Line Examples

- Basic Model



/* Declaration part*/

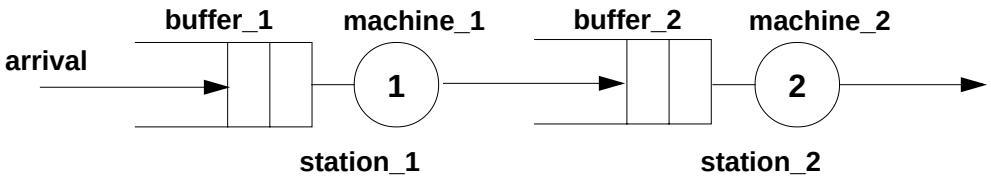
CONST arrival **:=** 0.5; **CONST** ServiceRate_1 := 0.75;
CONST ServiceRate_2 := 0.6;

/* System components part */

NODE buffer_1 **[**K**]** := 0;
NODE machine_1 **[**1**]** := 0;
NODE station_2 **[**K**]** := 0;
NODE num **[**K**]** := 0;

Production Line Examples

- Basic Model (2)

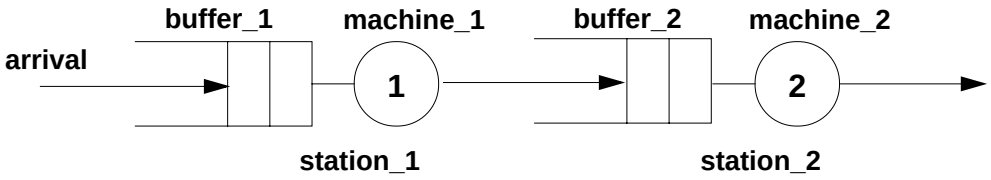


/* Rules part */

FROM EXTERN TO buffer_1, num **RATE** arrival;
FROM buffer_1 **TO** machine_1;
FROM machine_1 **TO** station_2 **RATE** ServiceRate_1;
FROM station_2, num **TO EXTERN RATE** ServiceRate_2;

Production Line Examples

- Basic Model (3)

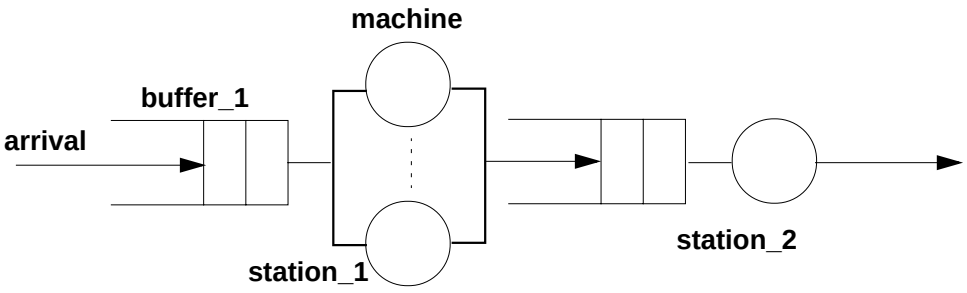


/* Results part */

```
PRINT   utilization_1 := UTIL (machine_1);
PRINT   utilization_2 := UTIL (station_2);
PRINT   WIP := MEAN (num);
PRINT   T := WIP / Arrival;
```


Production Line Examples

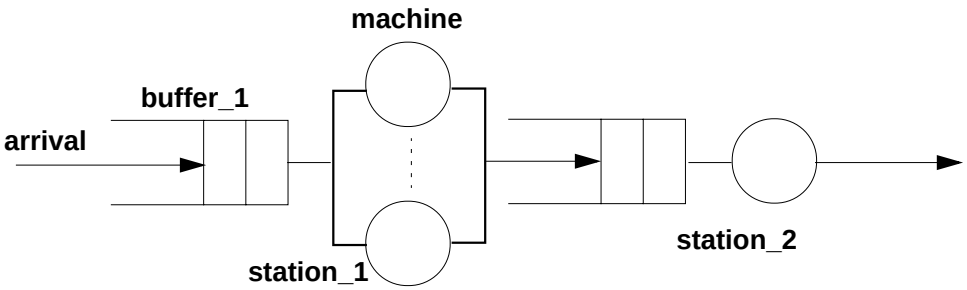
- Multiple Machines




```
CONST m := 4;

NODE buffer_1 [K]  := 0;
NODE machine [m]  := 0;
NODE station_2 [K]  := 0;
NODE num [K]  := 0;
```

Production Line Examples

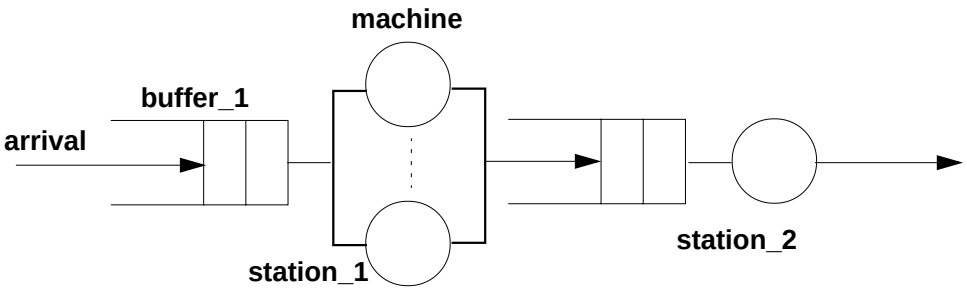
- Multiple Machines (2)




```
FROM EXTERN TO buffer_1, num RATE arrival;

FROM buffer_1 TO machine;
@<1..m> { IF (machine = #) FROM machine TO station_2
          RATE #*ServiceRate_1; }
FROM station_2, num TO EXTERN RATE ServiceRate_2;
```


Production Line Examples

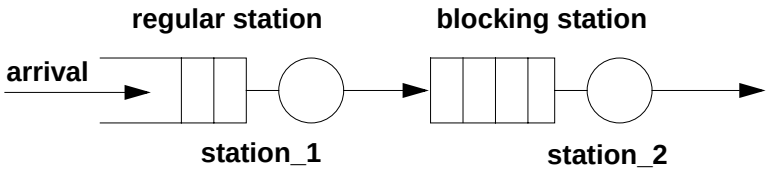
- Multiple Machines (3)




```
/* Mean number of active machines in station_1 */

PRINT  A :=  MEAN (machine);

/* Utilization of station_1 */

PRINT  utilization_1 :=  A/m;
```

Production Line Examples

- Finite Buffer (Blocking)

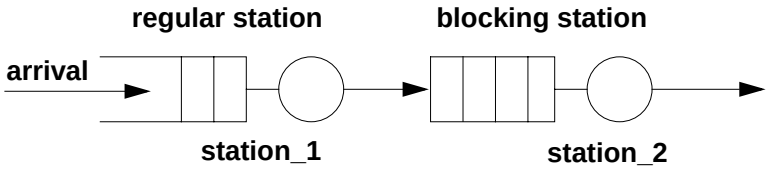


/* Definition of the system components */

NODE station_1 **[**K**]** **:=** 0**;**
NODE block **[**1**]** **:=** 0**;**
NODE station_2 **[**Capacity**]** **:=** 0**;**
NODE num **[**K**];**

Production Line Examples

- Finite Buffer (Blocking) (2)



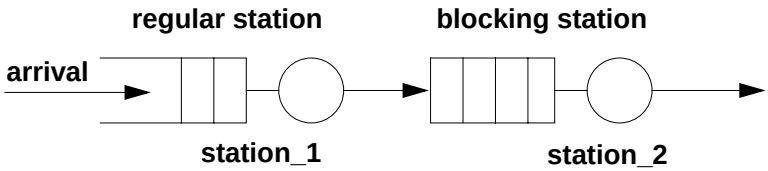
/* Definition of the arrivals */
FROM EXTERN TO station_1 **RATE** arrival;

/* Definition of the behavior of station_1 */
FROM station_1 **TO** block **RATE** ServiceRate _1;
FROM block **TO** station_2:

/* Definition of the behavior of station_2 */
FROM station_2 **TO EXTERN RATE** ServiceRate_2;

Production Line Examples

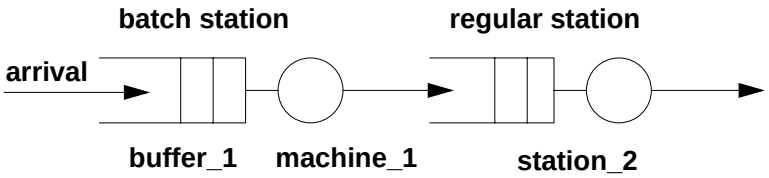
- Finite Buffer (Blocking) (3)




```
/* Definition of the Results */

PRINT   utilization_2  :=  UTIL (station_2);
PRINT   throughput := utilization_2 * ServiceRate_2;
PRINT   blockprob   :=  PROB (block =1);
PRINT   utilization_1 := PROB (station_1 > 0 OR block = 1);
PRINT   WIP = MEAN (num);
```


Production Line Examples

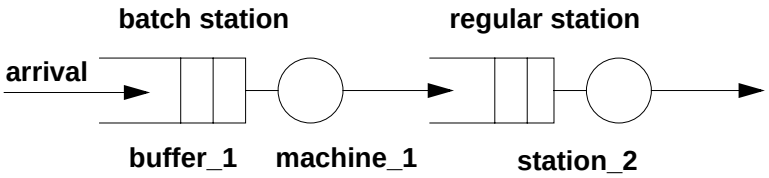
- Batch Processing




```
/* Declaration part*/

CONST    b = 5;                    /* Batch size */;

/*Definition of the system components */

NODE   buffer_1 [K]          := 0;
NODE machine_1 [b]           := 0;
NODE station_2 [K]           := 0;
NODE   num [K]               := 0;
```

Production Line Examples

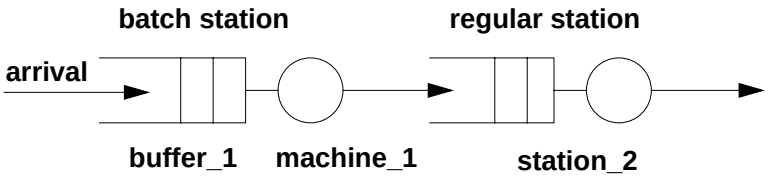
- Batch Processing (2)




```
/* Arrival of jobs */
FROM EXTERN  TO  num, buffer_1  RATE  arrival;

/* station_1 */
IF  (buffer_1 >= b)  FROM  buffer _1 (b)  TO  machine_1 (b) ;
FROM  machine_1 (b) TO  station_2 (b)  RATE ServiceRate_1;

 /* station_2 */
FROM  station_2,  num  TO EXTERN  RATE  ServiceRate_2;
```


Production Line Examples

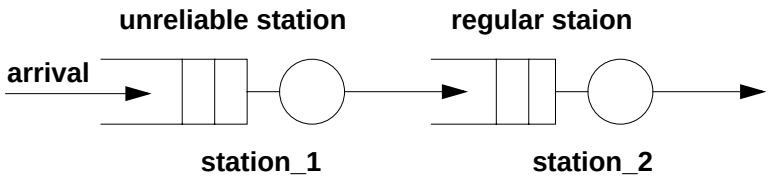
- Batch Processing (3)




```
/* Performance measures */

PRINT   utilization_2 := UTIL (station_2);
PRINT   throughput := utilization_2 * ServiceRate_2;
PRINT   p_zero := PROB (machine_1 = 0);
PRINT   utilization_1 := 1 - p_zero;
PRINT   WIP :=  MEAN (num);
PRINT   DIST num;
```

Production Line Examples

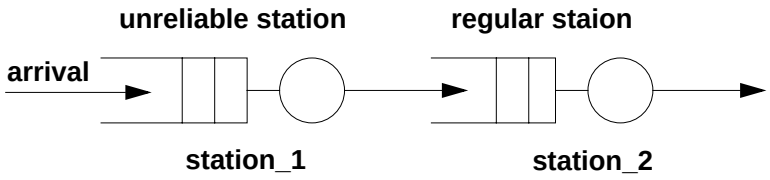
- Unreliable Machines




```
/* Declaration part */
ENUM      state_a  :=  {up, down};

/* Definition of the system components */
NODE    station_1 [K]       := 0;
NODE    station_2 [K]       := 0;
NODEnum [K]                 := 0;
NODEserver [state]          := up;
```


Production Line Examples

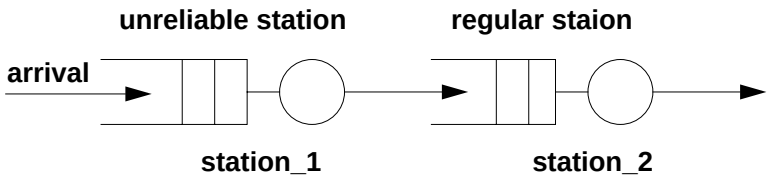
- Unreliable Machines (2)




```
/* Arrival of jobs */

FROM EXTERN   TO   num, station_1  RATE   arrival;

/* Failure and repair */

FROM   server [up]     TO   server [down]  RATE   1/mtbf;
FROM   server [down]   TO   server [up]    RATE   1/mttr;
```

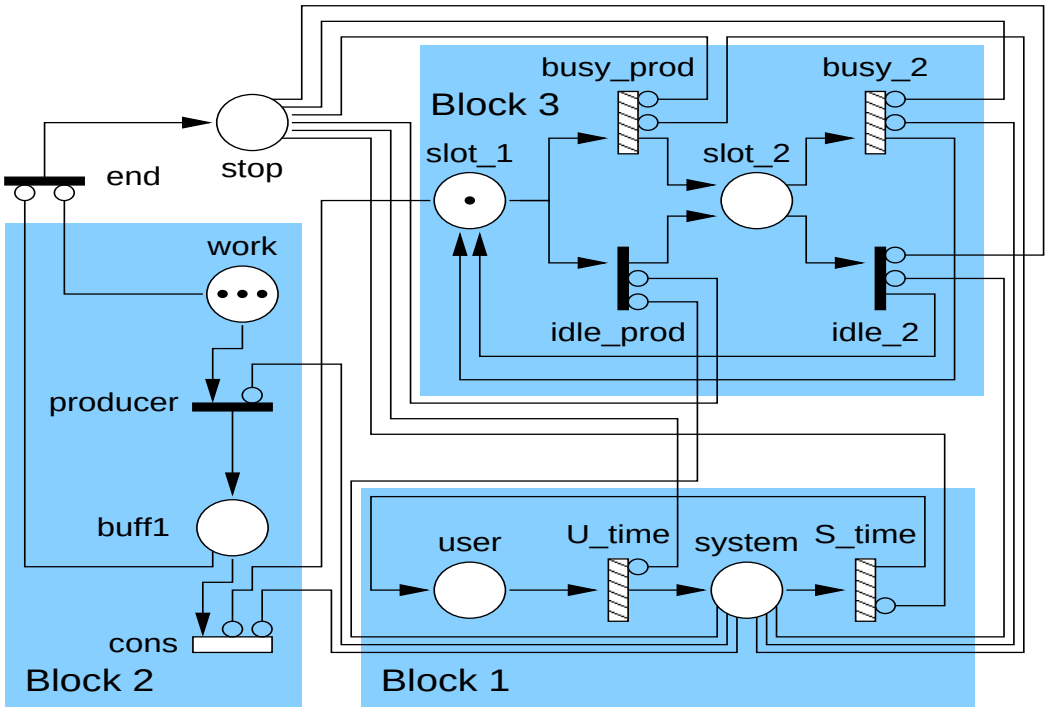
Production Line Examples

- Unreliable Machines (3)

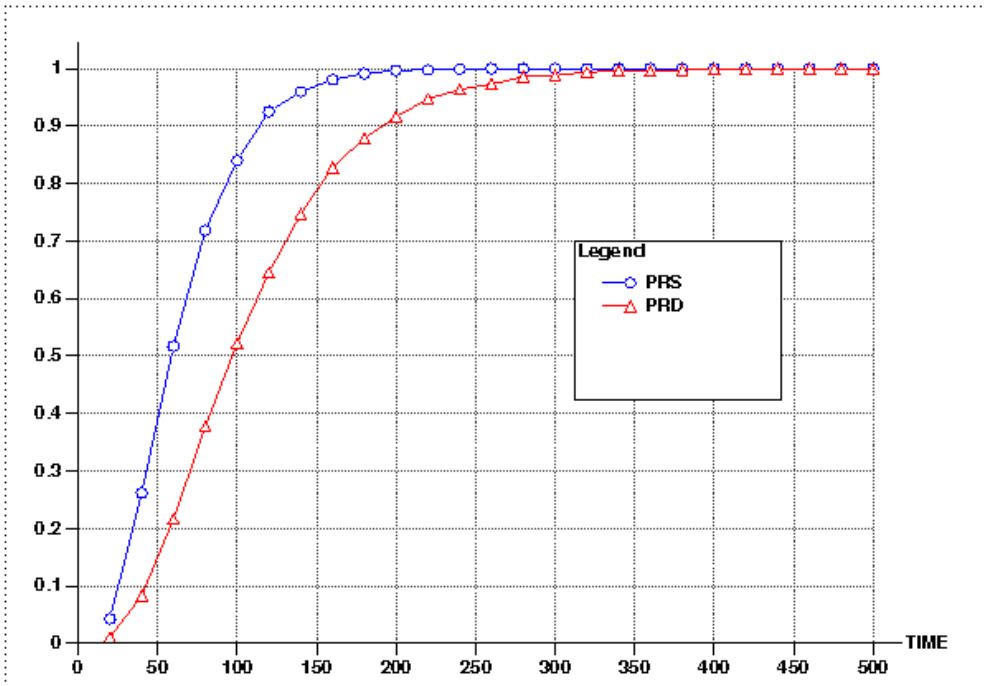



```
/* station_1 */
IF (server = up)  FROM  station_1  TO  station_2  RATE  ServiceRate_1;

/* station_2 */
FROM  station_2, num  TO EXTERN  RATE  ServiceRate_2;

/* Performance Measures */
PRINT  utilization_2  := UTIL (station_2);
PRINT  throughput_2  := utilization_2 * ServiceRate_2;
PRINT  upprob  :=  PROB  (server = up) ;
```


Preemption in a multitasking environment



Preemption in a multitasking environment



Preemption in a multitasking environment (2)

```
/* Constant declarations*/
CONST N := 3;        CONST prod_start := 0.5;    CONST prod_end := 1.5;
CONST U_time := 3;   CONST S_time := 1.0;        CONST busy_prod := 0.1;
CONST busy2 := 0.1;  CONST cons1 := 0.1;

/* Nodes for Block 1 */      /* Nodes for Block 2 */      /* Nodes for Block 3 */
NODE user[1] := 1;           NODE work[N] := 3;           NODE slot1[1] := 1;
NODE system[1];              NODE buff1[N];               NODE slot2[1];

/* Node indicating completion of service */
NODE stop[1] := 1;

/* Conditon under which the user may continue his work */
COND user_may_work := system = 0 AND stop = 0;
```

Preemption in a multitasking environment (3)

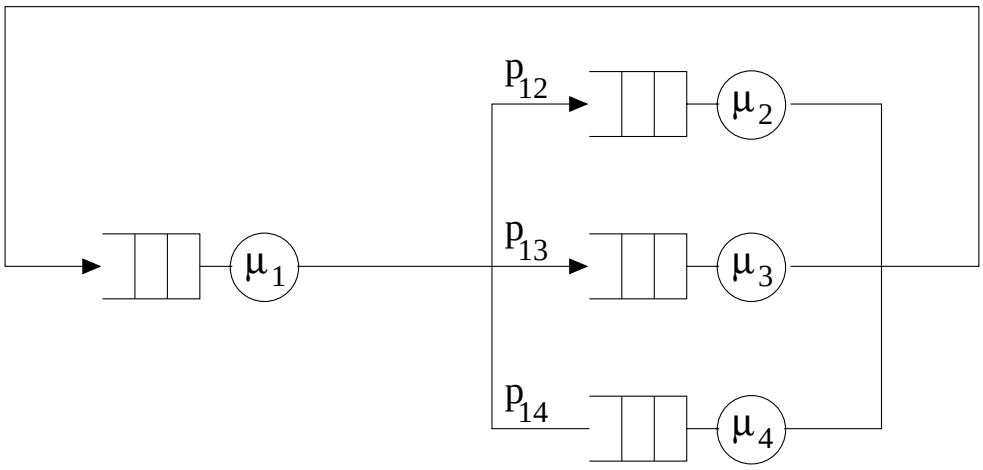
```
/* Dynamic behaviour of the System */

IF  user_may_work  FROM user  TO  system  RATE  U_time  PRD;
IF  (stop = 0 AND user = 0)   FROM system  TO  user  RATE  S_time  PRD;

IF  (slot2 = 0 AND system = 0)   FROM  work  TO  buff1  AFTER
prod_start..prod_end  PRD;

IF  (slot1 = 0 AND system = 0)   FROM  buff1  RATE  cons1;

IF  user_may_work FROM  slot1 TO  slot2  AFTER  busy_prod  PRD;
IF  (user_may_work AND work = 0)    FROM  slot1 TO slot2  PRIO 1;
IF   user_may_work  FROM slot2 TO  slot1  AFTER  busy2  PRD;
IF  (user_may_work AND buff1 = 0)    FROM  slot2  TO slot1  PRIO 1;

IF (work = 0 AND buff1 =  0)   TO  stop  PRIO  2;
IF  stop = 1      /* do nothing, just fire. */    RATE 1;
```


Preemption in a multitasking environment (4)

```
/* Definition of time points to be used in transient analysis */
TIME 20..500 STEP 20;

/* Results */

/* Mean number of jobs to be processed */
PRINT    work_left   :=   MEAN (work);


/* Probability that the work is completed */
PRINT  prob_work_complete  :=  PROB (stop > 0)t;


/* Graphical presentation */
PICTURE "service completion probability "
PARAMETER   TIME
CURVE   prob_work_complete;
```

IGL Intermediate Graphic Language

- Central-Server-model



IGL Intermediate Graphic Language

```
/*========== Central-Server-model ==================*/

/**-------------- Parameter declaration part----------------------*/

CONST K    := 10;
CONST mue1 := 3.5;
CONST mue2 := 0.9;
CONST mue3 := 2.3;
CONST mue4 := 1.2;
CONST p12  := 0.25;
CONST p13  := 0.35;
CONST p14  := 0.4;

/**------------- System component definition part ----------------------------*/

            NODE N1[K] := K;
@<2..4> { NODE N#[K]; }

/**------------- Prohibited states ---------------------------------*/

ASSERT  N1 + N2 + N3 + N4 = K;
```

IGL Intermediate Graphic Language

```
/*-------------Transition definition part ---------------------------------------------*/

FROM  N1  RATE mue1 THEN {
    @<2..4> { TO   N#   WEIGHT  p1#; }
}
@<2..4> { FROM N#  TO N1  RATE mue#; }


/*------------- Result part-------------------------------------------*/

@<1..4> { PRINT   rho# := PROB (N#>0); }        // utilization
@<1..4> { PRINT   n# := MEAN (N#); }             // mean queue length
@<1..4> { PRINT   DIST N#; }                    // distribution (probability of each
                                                       possible queue length)
@<1..4> { PRINT   lambda# := rho# * mue#; }    // throughput
@<1..4> { PRINT    t# := n# / lambda#; }        // mean time a job is in a node
```


IGL Intermediate Graphic Language

IGL Intermediate Graphic Language

```
/*------------- Picture part-----------------------------*/

PICTURE  "Distribution for queue lengths"
  CURVE DIST  N1, N2, N3, N4 ;

PICTURE  "lambdas_and_rhos"
  LIST  lambda1, lambda2, lambda3, lambda4, rho1, rho2, rho3, rho4
```

Invoking the MOSEL-ENVIRONMENT:

mosel2 -cs centralserver.msl --> centralserver.res --> centralserver.igl
igl centralserver.igl --> pictures

IGL Intermediate Graphic Language

Results provided by the tool `SPNP'

==========

Constants:

K = 10

mue1 = 3.5

mue2 = 0.9

mue3 = 2.3

mue4 = 1.2

p12 = 0.25

p13 = 0.35

p14 = 0.4

- -

Results:

__DIST N1 ___

0: 0.226490510324

10: 0.00523876082994

__DIST N2 ___

0: 0.247975421288

10: 0.00395268685905

IGL Intermediate Graphic Language

IGL Intermediate Graphic Language

__DIST N3 ___

0: 0.588022114438

10: 9.62301477005e-06

__DIST N4 ___

0: 0.0975734220455

10: 0.0244732959731

rho1 = 0.773509489676

rho2 = 0.752024578712

rho3 = 0.411977885562

rho4 = 0.902426577954

lambda1 = 2.70728321387

lambda2 = 0.676822120841

lambda3 = 0.947549136792

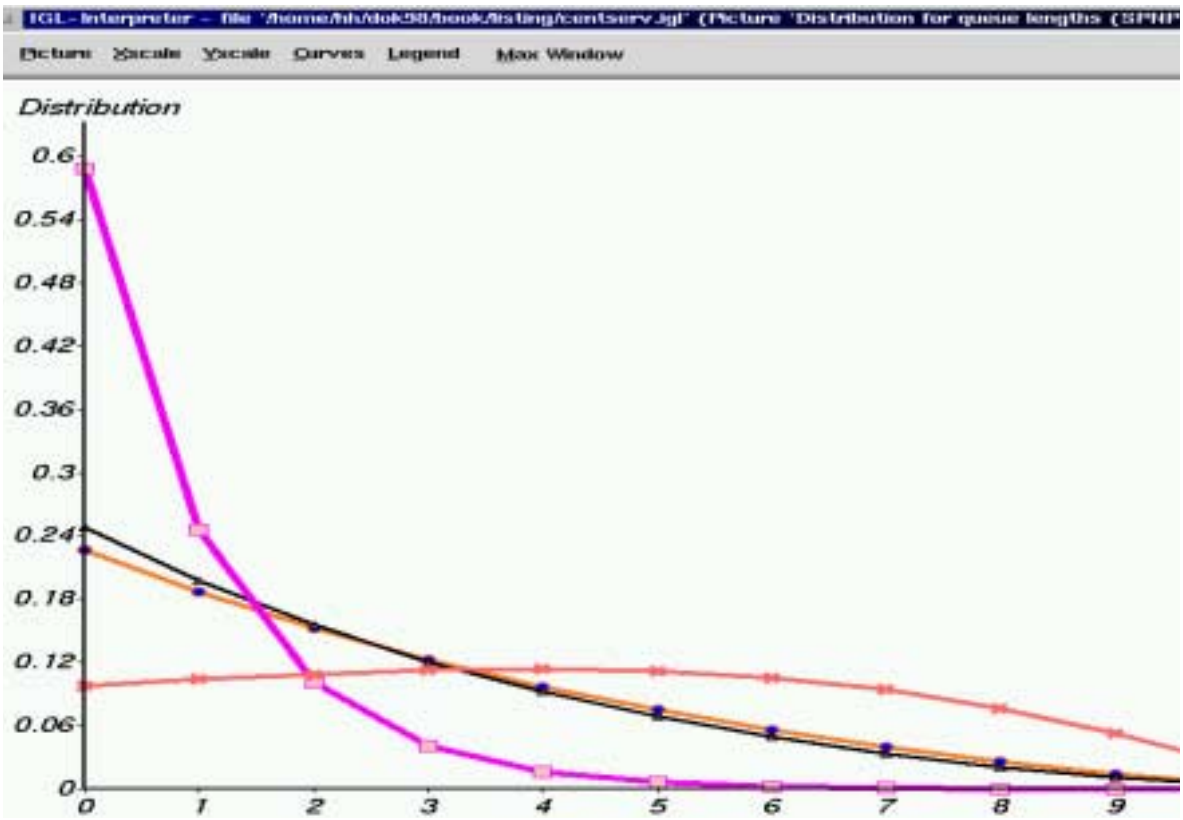
lambda4 = 1.08291189355

t1 = 0.965895587825

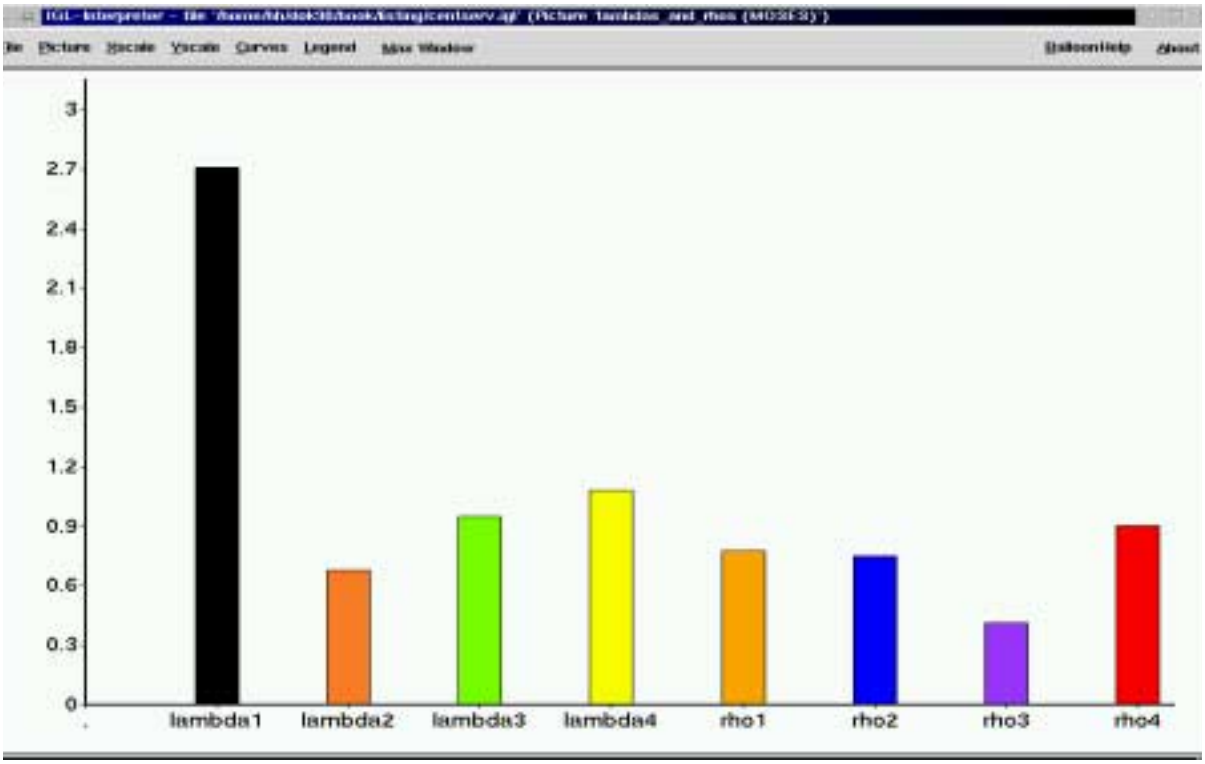
t2 = 3.56550339435

t3 = 0.720806197492

tr4 = 3.96046645608



IGL Intermediate Graphic Language



IGL Intermediate Graphic Language

Real Life Examples

- MOSEL has been successfully used to model and to analyze systems from the following domains:
- **Computer Systems:** UNIX Operating System, Polling Systems, Fork Join Systems, Terminal Systems, Multithreaded Architecture, Client Server,
  Multi Processor Systems
- **Communication Systems:** Cellular Mobil Networks, ATM-Multiplexer, Internet Router, Retrial Systems,
- **Manufacturing Systems:** Batch Systems, Wafer Production Systems, ClusterTools for Single Wafer Processing

Remarks

- **Availability**: MOSEL is working on Solaris and Linux platforms.
  An earlier version had been compiled successfully under Windows NT.
  The IGL-interpreter is written in Tcl/Tk. MOSEL is implemented in C.
  The MOSEL-Tool (MOSEL, IGL) is freeware.
- **Documentation**: Practical Performance Modelling - *Application of the MOSEL Language;* by Begain, K.; Bolch, G.; Herold, H., Kluwer Academic Publishers, 2001, 409 pages.
  The book serves as a reference guide to MOSEL and IGL and contains a lot of real life examples
- **Current State:** MOSEL contains translators to CSPL (suitable for SPNP v. 6.x) and to .TN (suitable for TimeNET 3.0) , and a translator to the Markov Chain Solver MOSES.
- http://www4.informatik.uni-erlangen.de/Projects/MOSEL/

Future Work and Related Work

- Modularization: Decomposition of the monolithic MOSEL model into functional components
- Integration of other Tools into the MOSEL environment
- Extend the language for the support of Fluid Stochastic Petri Nets
- Application to Special Systems
  - Computer Systems
  - Operating Systems
  - Communication Systems (Ethernet (CSMA/CD, Tokenring), FDDI, ATM, Cellular Mobil Networks)
  - Fault Tolerant Systems