Discrete-event simulation system Delsi 1.1

Programmer's Guide

CONTENTS

INTRODUCTION....3
INSTALLATION....4
1. SIMULATION LOGIC....5
1.1. Objects of model....5
1.2. Main simulation algorithm....7
1.3. Advantages of *Delsi* simulation logic....8
2. MODEL TIME....8
3. TRANSACTIONS....9
4. *Delsi* COMPONENTS....10
4.1. TModel....10
4.2. TScheduler....12
4.3. TBlock....13
4.4. TGenerator....15
4.5. TQueue....16
4.6. TStack....18
4.7. TQueuePrty....19
4.8. TServer....22
4.9. TStorage....24
4.10. TStoragePrty....26
4.11. TTerminator....28
4.12. TDivider....29
4.13. TAssembler....30
4.14. TCreator....31
4.15. TGate....32
4.16. TTabulator....33
4.17. TMultiRand....34
References....37

INTRODUCTION

The main idea of *Delsi* modeling is that your queuing formalization may be performed as an oriented graph with the nodes, which correspond to some processing objects (such as generators, queues, servers etc). The arcs of the graph correspond to the streams of transactions. Some user algorithms may control processing objects and transaction routing.

The simulation system is designed using object -oriented approach. The whole model and the processing objects (so called blocks) are implemented as Borland® *Delphi*™ components. The transactions are implemented as objects.

The user algorithms are implemented as reactions on events such as entering block, routing, exit from block and others. During the simulation transactions are being passed from one block to another. By use of the methods and properties of components it is possible to control the behavior of the model and obtain necessary statistical results.

From the end-user's point of view, *Delsi* allows him to use all the power of Delphi (GUI, OOP, and components) as an environment for developing a wide variety of simulation models, implemented as software products. *Delsi,* in combination with a standard PC and *Delphi* creates a non-expensive simulation workplace for developing valuable applications.

INSTALLATION

How to install Delsi?

- Extract delsi_*.zip into some directory, for instance, C: \DELPHI\DELSI
- Start Delphi
- Choose Componet|Install Packages
- Click "Add"
- Type the full file name C:\DELPHI\DELSI\delsi.bpl
- Click "Open"
- Click "Ok"

You should have now a new page on your component palette called *Delsi* with new components.

Don't forget to add the PATH of your installed units to *Project*|*Options*|*Directories/Conditionals*|*Search Path*.

1. SIMULATION LOGIC

1.1. Objects of model

Delsi is based on the Theory of Aggregate Models. The basic unit of an aggregate model is Piecewise Linear Aggregate (PLA).

Aggregate is an abstract object, which functions in time. It is capable to perceive entering signals *X*, to produce output signals *Y* and to be in each instant in a condition *Z*. The dynamics of PLA has an event-driven nature. Two key operations correspond to *Delsi* aggregates: *activation* and *odering next activation time*.

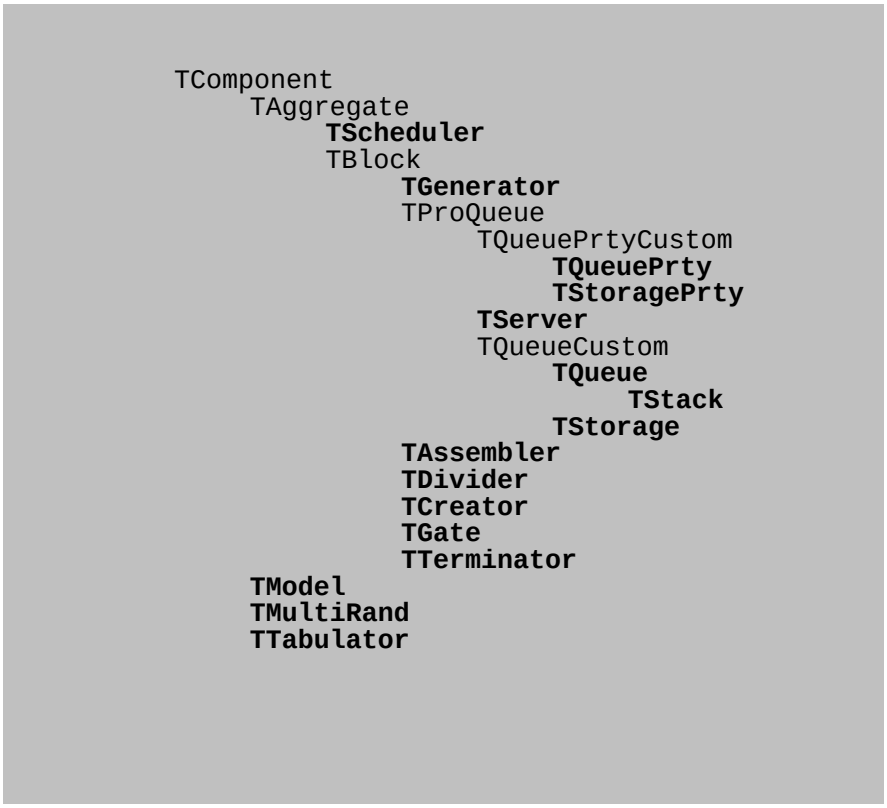
There are two kinds of aggregates in Delsi: *schedulers* and *blocks*.

Scheduler is an aggregate, which just handles some user-processed event. It does not operate with transactions.

Block is an aggregate, which sends and receives transactions.

Each block is characterized by two states: *Ready/not ready to receive transaction* and *Ready/not ready to give transaction*. These states are necessary conditions for transaction transfer. Generally, the behavior of each block is described as a reaction to the following events: *OnEnter* (transaction is entering the block), *OnRouting* (the block is *Ready to give* and it needs to send the transaction to another block), *OnExit* (transaction leaves the block). For some blocks there are additional specific events, which determine their behaviour.

The inheritance of aggregates has the following structure.



Activation is an event initiated by the changes of model time. The activation of scheduler is just the initiating of user-processed event. For the generator, activation is the producing of a new transaction. For servers, queues, storages it is the finishing of the waiting period for a certain transaction.

Ordering next activation time takes place during the handling of the certain aggregate events. For example, when the transaction leaves the generator we order next activation time (the time interval till the next generation) by handling *OnExit* event. When transaction enters into a server or storage we order the next activation time (the service time) by handling *OnEnter* event. During ordering next activation time the record with the following fields will be inserted into the system calendar (List of Future Events): Block, Transaction/ **nil,** Activation Time.

FIFO rule of activation: If several aggregates should be activated at the same time they will be activated with FIFO rule (First ordered - first activated).

Transaction is a dynamic object, which moves through the fixed structure of blocks. They resemble GPSS transactions but they can have an arbitrary structure.

Delsi has the following limitation: One transaction may be only in one block at the same time.

1.2. Main simulation algorithm

The simulation logic is controlled by the main simulation algorithm, which is performed in pseudo-programming language as shown below. The main cycle of the simulation algorithm scans the system calendar. In case of *Delsi*, the system calendar is called the List of Future Events (LFE), which keeps the interior events of aggregates.

```
repeat
     Take the next element form the List of Future Events;
     ModelTime:=NewTime;
     Model.OnNewTime; // You can check what has happened
     If Aggregate is Scheduler then
          Activate(Scheduler)
     else
          begin
               Activate (Block, Transaction);
               Insert this Block into the List of Current Events;
               Using List of Current Events do all possible transaction passes;
     end;
until ModelTime<LimitTime;
```

List of Current Events (LCE) includes all the blocks, which are in the state *Ready to Give*. The following algorithm controls the implementation of all possible passes.

```
repeat
     for all blocks in the LCE do
     begin
          Block.OnRouting; // Pass transaction to another block
          if not Block.ReadyToGive then
               Remove Block from the LCE;
     end;
until at least one pass have been done;
```

The user can route the transaction in the routine of *OnRouting* event in the following way:

```
if Condition then
     ThisBlock.PassTo(Block1)
else
     ThisBlock.PassTo(Block2);
```

The procedure *PassTo* does the following:

```
if AnotherBlock.ReadyToReceive(PassedTransaction) then
begin
     ThisBlock.ExitFromBlock;   // The transaction leaves this block
     ThisBlock.OnExit;          // User-defined handling
     AnotherBlock.OnEnter;      // User-defined handling
     AnotherBlock.EnterToBlock; // The transaction enters to another block
     Model.OnAfterPass;         // User-defined handling
end;
```

1.3. Advantages of *Delsi* simulation logic

Main simulation algorithm does not know about transactions

As we have seen, the main simulation algorithm operates with the states and events of blocks. Transactions are generated, moved and terminated during different operations with blocks. The main simulation algorithm knows almost nothing about the transactions. Thus, the speed of the main simulation algorithm does not depend on the number of transactions in the system.

Direct access to transactions in the block

Independently of the number of transactions in the block, the search and removal of certain transaction in the block is one-step operation. Let's imagine the storage with 100,000 transactions. In some moment of the model time one of them has to be removed. The node of List of Future Events stores the address of the transaction and address of the storage. Because transactions are stored in the storage in a bi-directional list, this particular transaction will be found and removed directly. That is why the term of activation and exiting does not depend on the number of transactions in storage. The same rule applies to queues with limited waiting time. Generally, for all blocks of *Delsi* there are no cycles during entering, activation or exiting. So, the number of transactions in the model does not influence the performance.

All time dependences are concentrated in LFE

The blocks place transactions independently of their activation time. The List of Future Events is a single data structure where all time dependences are maintained. In simulation systems with intensive load, the length of LFE may reach hundreds of thousands of items. That is why LFE maintenance plays such a decisive role in the performance. *Delsi* is designed in such way that I/O performance of LFE has binary-logarithmic dependence on its length.

2. MODEL TIME

The model time is not physical but modeled time. Before simulation start-up and after model reset the model time is equal to 0.

```
function ModelTime: real;
```

Returns current model time.

3. TRANSACTIONS

Declaration

```
TTransaction = class(TObject)
```

Methods

```
procedure TTransaction.SetPrty(Prty: byte);
```

Sets priority level *Prty* for the transactioin

```
procedure TTransaction.SetPreempt;
```

Makes the transaction preemptive.

```
procedure TTransaction.SetNonPreempt;
```

Makes the transaction non-preemptive.

```
function TTransaction.GetPrty: byte;
```

Returns the priority of the transaction.

```
function TTransaction.IsPreempt: boolean;
```

Returns *True* if the transaction is preemptive. Otherwise returns *False*.

```
function TTransaction.GetTransID: longint;
```

Returns the transaction ID. IDs of all "alive" transactions are unique but newly generated transaction may repeat the ID of terminated one.

Inheritance

It is very important that you can redefine *TTransaction* to obtain the new customized fields. For instance,

```
MyTransaction = class (TTransaction);
public
  MyField1: integer;
  MyField2: real;
end;
```

When you redefine *TTransaction* you have to inform the internal simulation manager about that new redefinition. Do this by calling method *TModel.SetTransactionClass* before start of simulation:

```
Model.SetTransactionClass(MyTransaction);
```

When you need to use your own fields, do this in the following way.

```
procedure TForm1.EntranceExit(Sender: TBlock; Trans: TTransaction);
begin
    (Trans as MyTransaction).MyField2:=ModelTime;
end;
```

4. *Delsi* COMPONENTS

4.1. TModel

Declaration

```
TModel = class(TComponent)
```

Purpose

TModel is a fundamental component, which is responsible for the whole model functioning. With help of *TModel* we can start and stop the simulation process or clear statistics collected in the blocks. One more useful feature of *TModel* is the possibility of registration of transaction passes and fixing the moments of time changes. There can be only one *TModel* component in an application.

Properties

```
property HeapSize: byte;
```

Before the simulation starts-up the application allocates a cut of memory. In *HeapSize* you can set the size of allocated memory in Megabytes. The range of possible values is from 1 to 128. The default value is 4.

```
property PageSize: integer;
```

All dynamic objects of *Delsi*, like transactions, elements of LFE and LCE are stored in memory pages. This property sets the page size in bytes. The range of possible values is from 1024 to 32768. The default value is 1024.

Methods

```
procedure ClearStatistics;
```

Clears statistics of all blocks. As a rule, stationary stochastic systems have transitional phase in their initial period of time. If the contributor wants to evaluate parameters of a system in its stable state, the transitional process brings an error to outcomes. We can cut off the errors by clearing statistics after the transient phase.

```
procedure Reset;
```

This procedure resets the model into its initial state so, that it becomes ready for the next run. Use this procedure when you need several simulation runs with changing input parameters.

```
procedure SetTransactionClass(TransClass: Tclass);
```

You need this method when you redefine class TTransaction to obtain your own customized structure of transaction. Use this procedure before simulation run (i.e. be fore first calling *TModel.Simulate*).

```
procedure Simulate(TLimit: real);
```

Starts simulation run. The simulation will proceed until reaching a value *TLimit* by model time.

```
procedure Stop;
```

Stops simulation run.

Events

```
TAfterPassEvent = procedure(Sender: TBlock;        // sending block
                            Receiver: TBlock;      // receiving block
                            Trans: TTransaction)   // passed transaction
                  of object;
property OnAfterPass: TAfterPassEvent;
```

The event occurs after the transaction is passed from one block to another.

```
TBeforeModelGoOnEvent = procedure of object;
property OnBeforeTimeGoOn: TBeforeModelGoOnEvent;
```

This event occurs before model running and before blocks' events OnBeforeTimeGoOn. So, it's the first *Delsi* event at all.

```
TDeadlock = procedure of object;
property OnDeadlock: TDeadlock;
```

This event is initiated after detection of deadlock in the simulated system. The deadlock in *Delsi* means that the List of Future Events is empty.

```
TNewTimeEvent = procedure(Aggregate: Taggregate;    // activated aggregate
                          Trans: TTransaction)      // nil or activated transaction
                of object;
property OnNewTime: TNewTimeEvent;
```

The event occurs when model time changes the value. Parameter *Aggregate* refers to activated aggregate (block or scheduler). *Trans* is the transaction, which should leave the block (server, queue or storage). If the activated aggregate is a generator or scheduler, *Trans* is equal to **nil**.

4.2. TScheduler

Declaration

```
TScheduler = class(TAggregate)
```

Purpose

TScheduler is intended to initiate the events through some intervals of simulation time. By use of this event, the user can change the parameters of the model, stop simulation run, clear statistics or lock/unlock gates.

Methods

```
procedure NextTime(ActivationTime: real);
```

Sets the period of time till the next activation.

Events

```
TBeforeTimeGoOnEvent = procedure(Sender: TAggregate) of object;
property OnBeforeTimeGoOn: TBeforeTimeGoOnEvent;
```

The event occurs before simulation run. We can use it to do any user-defined action before simulation, for example, to initialize some parameters. This event is especially useful for planning the first user-defined procedure used during simulation run. We plan the next event using method *NextTime*.

```
TPlannedEvent = procedure(Sender: TAggregate) of object;
property OnPlanned: TPlannedEvent;
```

This event is a result of activation, which happens after expiration of *ActivationTime*. By handle of this event we can do any possible changes for the model. If you need to order the next activation, use *NextTime* again.

4.3. TBlock

Declaration

```
TBlock = class(TAggregate)
```

Purpose

TBlock is an ancestor of all *Delsi* blocks. Here we describe the methods and events common for all blocks.

Methods

```
procedure ClearStatistics;
```

Clears accumulated statistics in the block. When *TModel.ClearStatistics* is being executed, it calls the method *ClearStatistics* for all blocks of a model.

```
function Count: longint;
```

Returns the current number of transactions in the block.

```
function Entries: longint;
```

Returns the total number of transactions, which have entered into the block..

```
function Exits: longint;
```

Returns the total number of transactions, which have exited from the block.

```
function IsReadyToReceive(Trans: TTransaction): boolean;
```

Returns *True* if the block is ready to receive transaction pointed by *Trans.*

```
function Pass(Block: TBlock): boolean;
```

Passes current transaction to the block *Block.* If transaction is successfully passed, the function returns *True*. Use this method only when you handle *OnRouting*, *OnPreempt, OnRelease* and *OnTimeFinish* events.

Events

```
TOnEnterToBlock = procedure(Sender: TBlock; // This block
                            Trans: TTransaction) // Entering transaction
                  of object;
property OnEnter: TOnEnterToBlock;
```

The event occurs when transaction enters into the bloc k. It is not applicable for *TGenerator.*

```
TOnExitFromBlock = procedure(Sender: TBlock; // This block
                             Trans: TTransaction)// Exiting transaction
                   of object;
property OnExit: TOnExitFromBlock;
```

The event occurs when transaction leaves the block. It is not applicable for *TTerminator.*

```
TOnRoutingEvent = procedure(Sender: TBlock; // Sending block (this block)
                            Trans: TTransaction) // Passed transaction
                  of object;
property OnRouting: TOnRoutingEvent;
```

Processing this event you can route transaction to another block with the help of *Pass* method. Using Delphi's power you can create very sophisticated procedures of routing.

4.4. TGenerator

Declaration

```
TBlock = class(TBlock)
```

Purpose

TGenerator produces one transaction per activation. It is commonly used source of transactions in the model. We use it when we need to simulate arrival of new entities (transactions) to the model. Usually, the arrivals have some rate described by probability distribution. In order to simulate sequential arrivals, we need to order next activation (i.e. next transaction generation) when transaction leaves the generator. Assigning random numbers to *ActivationTime*, we simulate statistical properties of the arrival rate.

Methods

```
function AverageTime: extended;
```

Returns the average time between the moments when transactions leave the generator.

```
function DeviationTime: extended;
```

Returns the standard deviation of time between the moments when transactions leave the generator.

```
procedure NextTime(ActivationTime: real);
```

Sets the time to the next activation (generation of transaction).

Events

```
TOnAfterGenerationEvent = procedure(Sender: TBlock; Trans: TTransaction) of
                          object;
property OnAfterGeneration: TonAfterGenerationEvent;
```

The event occurs right after generation of new transaction. It's a good time to set the transaction properties like priority, preemptive property or fields defined by user.

```
TBeforeTimeGoOnEvent = procedure(Sender: TAggregate) of object;
property OnBeforeTimeGoOn: TBeforeTimeGoOnEvent;
```

The event occurs before simulation run. We use it to order the time of generation of the first transaction. After that we do it with help of *NextTime* method.

```
property OnExit: TOnExitFromBlock;
```

The event occurs when transaction leaves the block. It is a good moment to order the next transaction generation by use of *NextTime* method.

```
property OnRouting: TOnRoutingEvent;
```

See 3.3. TBlock

4.5. TQueue

Declaration

```
TQueue = class(TQueueCustom)
```

Purpose

This component simulates simple FIFO queue. It handles transactions in accordance with the rule "First input – first output". The queue may have limited capacity. Another useful feature is the possibility to limit a waiting period in the queue. You can do this by the ordering the activation when a transaction enters the queue. If the number of transactions in the queue is less than its capacity, the queue is in the state of " *Ready to Receive*". If the queue keeps one or more transactions, it is in the state of "*Ready to Give*".

Properties

```
property Capacity: longint;
```

Capacity is the greatest possible number of transactions in the queue. If the number of transactions is equal to capacity, the queue is " *Not Ready to Receive*". If Capacity is equal to 0, the possible number of transactions in the queue is unlimited.

Methods

```
function AverageCount: extended;
```

Returns the average number of transaction in the queue (average length).

```
function AverageTime: extended;
```

Returns the average time spent in the queue.

```
function Count: longint;
```

See 3.3. TBlock

```
function DeviationTime: extended;
```

Returns the standard deviation of the time spent in the queue.

```
function IsReadyToReceive(Trans: TTransaction): boolean;
```

Returns *True* if the queue is "*Ready to Receive*" transaction *Trans*.

```
function MaxCount: longint;
```

Returns maximal number of transactions in the queue (maximal length).

```
procedure NextTime(ActivationTime: real);
```

Limits the waiting time for the entering transaction by the value of *ActivationTime*. Use this method only when handle *OnEnter* event.

```
function SAverageTime: extended;
```

Returns average non-zero time spent by transactions in the queue.

```
function SDeviationTime: extended;
```

Returns the standard deviation of the non-zero time spent by transactions in the queue.

```
function TimeLimitExits: longint;
```

Returns the number of transactions, which have abandoned the queue because of the end of waiting period.

```
function Usage: extended;
```

Returns a relative part of the time when the queue was in use.

```
function ZeroEntries: longint;
```

Returns the number of transaction entries into the queue, when the queue was empty.

Events

```
property OnEnter: TOnEnterToBlock;
```

See 3.3. TBlock. If you want to limit the waiting time in the queue, do this by processing this event with the help of *NextTime* method.

```
property OnExit: TOnExitFromBlock;
```

See 3.3. TBlock.

```
property OnRouting: TOnRoutingEvent;
```

See 3.3. TBlock

```
TOnTimeFinish = procedure(Sender: TBlock; // This queue
                          Trans: TTransaction) // The transaction whose time is finished
                of object;
property OnTimeFinish: TOnTimeFinish;
```

This event occurs when admissible latency period for the transaction is finished. We call this moment "activation of the queue". Here you can determine what will happen further with the transaction. One of alternatives is to pass the transaction to another block. If you don't pass the transaction to another block, or if you don't handle this event at all, the transaction will be terminated.

4.6. TStack

Declaration

```
TStack = class(TQueue)
```

Purpose

This component simulates simple LIFO queue. It handles transactions in accordance with the rule "Last input – first output". Besides, this component repeats all properties, methods and events of *TQueue*.

4.7. TQueuePrty

Declaration

```
TQueuePrty = class(TQueuePrtyCustom)
```

Purpose

TQueuePrty differs from *TQueue* by the discipline of transaction keeping. It keeps them in accordance with the rule "First input – first output in its priority level". So, the transactions with higher priority will leave the queue first.

Another distinguishing feature of *TQueuePrty* is the following. Let's imagine that the queue is full, i.e. the number of transactions is equal to the queue capacity, and a transaction tries to enter into the queue. Assume that this transaction has pre-emptive priority with the level higher than the lowest priority of transactions in the queue. In this case high-priority pre-emptive transaction will displace the lowest-priority transaction. This operation is called *preempting*. Preempted (displaced) transactions may be passed to the other blocks or terminated depending on handling procedure of *OnPreempt* event.

Properties

```
property Capacity: longint;
```

See 3.5. TQueue

```
property Preemptive: boolean;
```

The preempting is possible if *Preemptive* is *True.*

Methods

```
function AverageCount: extended;
```

See 3.5. TQueue

```
function AverageTime: extended;
```

See 3.5. TQueue

```
function Count: longint;
```

See 3.3. TBlock

```
function DeviationTime: extended;
```

See 3.5. TQueue

```
function IsReadyToReceive(Trans: TTransaction): boolean;
```

Returns *True* if the queue is "*Ready to Receive*" transaction *Trans*. It takes place in the following cases:

- The capacity is unlimited;
- The number of transactions in the queue is less then its capacity;
- Entering transaction pointed by *Trans* has preemptive priority higher than the priority of at least one transaction in the queue.

```
function MaxCount: longint;
```

See 3.5. TQueue

```
procedure NextTime(ActivationTime: real);
```

See 3.5. TQueue

```
function PreemptExits: longint;
```

Returns the number of transactions, which have abandoned the queue due to priority preempting.

```
function SAverageTime: extended;
```

See 3.5. TQueue

```
function SDeviationTime: extended;
```

See 3.5. TQueue

```
function TimeLimitExits: longint;
```

Returns the number of transactions, which have abandoned the queue because of the end of admissible waiting period.

```
function Usage: extended;
```

See 3.5. TQueue

```
function ZeroEntries: longint;
```

See 3.5. TQueue

Events

```
property OnEnter: TOnEnterToBlock;
```

See 3.3 TBlock, 3.5 TQueue

```
property OnExit: TOnExitFromBlock;
```

See 3.3. TBlock

```
TOnPreempt = procedure(Sender: TBlock; // This queue
                       Trans: TTransaction) // Preempted transaction
             of object;
property OnPreempt: TonPreempt;
```

Handling this event, you can determine what will happen with the preempted low–priority transaction. You can pass preempted transaction to another b lock. If you don't pass the transaction or if you don't handle this event at all, the transaction will be terminated.

```
property OnRouting: TOnRoutingEvent;
```

See 3.3. TBlock

```
property OnTimeFinish: TOnTimeFinish;
```

See 3.5. TQueue

4.8. TServer

Declaration

```
TServer = class(TProQueue)
```

Purpose

TServer simulates a serving process. Only one transaction can be served at any moment of time. The transaction is being served during the time defined by *NextTime* method in the procedure of handling *OnEnter* event.

As *TQueuePrty* component, *TServer* can handle preempting. Preemptive high-priority transaction preempts the service of low -priority transaction. The preempted transaction may be passed to another block or terminated. The third alternative is that the serving preempted transaction may be *postponed*. When a high-priority transaction leaves the server, the postponed transaction will be reset on serving for the rest of service time. The server can store only one postponed transaction per priority level. Postponed transactions are kept in the stack ordered by priority. Note, there is a difference between the number of transactions which are being served (may be 0 or 1) and the number of transactions in the server (may be equal up to number of priority levels in your model).

Properties

```
property Preemptive: boolean;
```

The preempting is possible if *Preemptive* is *True.*

Methods

```
function AverageCount: extended;
```

Returns the average number of transactions in the server.

```
function AverageTime: extended;
```

Returns the average time spent by transactions in the server.

```
function Count: longint;
```

See 3.3. TBlock

```
function DeviationTime: extended;
```

Returns the deviation of time spent by transactions in the server (including the time of postponing).

```
function IdleForExit: boolean;
```

Returns *True* if the current transaction in the server is already served. In this case the transaction is just waiting for exit.

```
function IsReadyToReceive(Trans: TTransaction): boolean;
```

Returns *True* if the server is "*Ready to Receive*" transaction *Trans*. It takes place in the following cases:

- The server is empty.
- The entering transaction pointed by *Trans* has preemptive priority higher than the priority of the transaction, which is served.

```
function MaxCount: longint;
```

Returns the maximal number of transactions in the server.

```
procedure NextTime(ActivationTime: real);
```

Sets the service time for the transaction entering into the server. The service time is equal to *ActivationTime*. Use this method while handle *OnEnter* event.

```
procedure Postpone;
```

Postpone the service of preempted transaction. Use this method only handling *OnPreempt* event.

```
function PreemptExits: longint;
```

Returns number of transactions, which have abandoned the serve r due to priority preempting.

```
function Usage: extended;
```

Returns a relative part of the time when the server was in use.

Events

```
property OnEnter: TOnEnterToBlock;
```

See 3.3. TBlock. The event occurs when transaction enters into the block. It's the time to define the service time using *NextTime* method.

```
property OnExit: TOnExitFromBlock;
```

See 3.3. TBlock

```
TOnPreempt = procedure(Sender: TBlock;       // This server
                       Trans: TTransaction) // Preempted transaction
             of object;
property OnPreempt: TOnPreempt;
```

Handling this event, you can determine what will happen with the preempted low–priority transaction. Your can pass transaction to another block or postpone its service. If you don't do it or if you don't handle this event at all, the transaction will be terminated.

```
property OnRouting: TOnRoutingEvent;
```

See 3.3. Tblock

4.9. TStorage

Declaration

```
TStorage = class(TQueueCustom)
```

Purpose

TStorage may be described as a server able to serve several transactions simultaneously. It is necessary to notice, that *TStorage* does not support preempting.

Properties

```
property Capacity: longint;
```

Capacity is the greatest possible number of transactions, which could be served in the storage. If the number of transactions is equal to capacity, the storage is " *Not Ready to Receive*". If Capacity is equal to 0, the possible number of transactions in the storage is unlimited.

Methods

```
function AverageCount: extended;
```

Returns the average number of transactions in the storage. You can determine the average filling of the storage as a ratio of *AvarageCount* to *Capacity*.

```
function AverageTime: extended;
```

Returns the average time spent by transactions in the storage.

```
function Count: longint;
```

See 3.3. TBlock

```
function DeviationTime: extended;
```

Returns the deviation of time spent by transactions in the storage.

```
function IsReadyToReceive(Trans: TTransaction): boolean;
```

Returns *True* if the storage is " *Ready to Receive*" transaction *Trans*. The function returns *True* if the *Capacity* is 0 or the number of transactions is less than *Capacity*.

```
function MaxCount: longint;
```

Returns the maximal number of tran sactions in the storage.

```
procedure NextTime(ActivationTime: real);
```

Sets the service time for the transaction entering the storage. Use this method handling *OnEnter* event.

```
function Usage: extended;
```

Returns the relative part of time when the storag e was in use.

Events

```
property OnEnter: TOnEnterToBlock;
```

The event occurs when transaction enters into the storage. On this event you define the service time by use of *NextTime* method.

```
property OnExit: TOnExitFromBlock;
```

See 3.3. TBlock

```
property OnRouting: TOnRoutingEvent;
```

See 3.3. TBlock

4.10. TStoragePrty

Declaration

```
TStoragePrty = class(TQueuePrtyCustom)
```

Purpose

Additionally to the possibilities of *TStorage*, this component supports priority preempting. The preempting in *TStoragePrty* is similar to preempting in *TQueuePrty* and *TServer*. In contrast to *TServer*, it does not support the postponed service.

Properties

```
property Capacity: longint;
```

See 3.9. TStorage

```
property Preemptive: boolean;
```

The preempting is possible if *Preemptive* is *True.*

Methods

```
function AverageCount: extended;
```

See 3.9. TStorage

```
function AverageTime: extended;
```

See 3.9. TStorage

```
function Count: longint;
```

See 3.3. TBlock

```
function DeviationTime: extended;
```

See 3.9. TStorage

```
function IsReadyToReceive(Trans: TTransaction): boolean;
```

Returns *True* if the queue is "*Ready to Receive*" transaction *Trans*. The function returns *True* in the following cases:

- The capacity is unlimited;
- The number of transactions in the storage is less then its capacity;
- The entering transaction pointed by *Trans* has preemptive priority higher than priority of the transaction, which is being served.

```
function MaxCount: longint;
```

See 3.9 TStorage

```
procedure NextTime(ActivationTime: real);
```

See 3.9. TStorage

```
function PreemptExits: longint;
```

Returns the number of transactions, which have abandoned the storage due to priority preempting.

```
function Usage: extended;
```

See 3.9. TStorage

Events

```
property OnEnter: TOnEnterToBlock;
```

See 3.3. TBlock, 3.9. TStorage

```
property OnExit: TOnExitFromBlock;
```

See 3.3. TBlock

```
TOnPreempt = procedure(Sender: TBlock; // This storage
                       Trans: TTransaction) // Preempted transaction
             of object;
property OnPreempt: TonPreempt;
```

Handling this event, you can determine what will happen with the preempted low-priority transaction. You can pass preempted transaction to another block. If you don't pass the transaction or if you don't handle this event at all, the transaction will be terminated.

```
property OnRouting: TOnRoutingEvent;
```

See 3.3. TBlock

4.11. TTerminator

Declaration

```
TTerminator = class(TBlock)
```

Purpose

Transactions enter this block to be terminated. When you handle *OnEnter* event, the transaction is still accessible and you have a possibility to get some information about it. *TTerminator* is always "*Ready to Receive*".

Events

```
property OnEnter: TOnEnterToBlock;
```

See 3.3. TBlock.

4.12. TDivider

Declaration

```
TDivider = class(TBlock)
```

Purpose

Splits the arrived transaction into several transactions. The new transactions have the same priority and ability to preempt just as their parent. When divider emits transactions, parent transaction goes last. This block is "*Ready to Receive*" and "*not Ready to Give*" if it is empty. If it is not empty, it is "*not Ready to Receive*" and "*Ready to Give*".

With the purpose of routing you may need to distinguish parental and generated transactions. You can do this by handling *OnExit* or *OnRouting* events. If *TDivider.Count* returns 1, it's a parental transaction.

Methods

```
function IsReadyToReceive(Trans: TTransaction): boolean;
```

See 3.3. TBlock

Properties

```
property Capacity: longint;
```

The number of the output transactions obtained in the outcome of splitting.

Events

```
property OnEnter: TOnEnterToBlock;
```

See 3.3. TBlock

```
property OnExit: TOnExitFromBlock;
```

See 3.3. TBlock

```
property OnRouting: TOnRoutingEvent;
```

See 3.3. Tblock

4.13. TAssembler

Declaration

```
TAssembler = class(TBlock)
```

Purpose

TAssembler assembles several arrived transactions into one. Actually, the first entering transaction remains alive. The rest of the transactions in the bundle will be terminated. This block is "*Ready to Receive*" and "*not Ready to Give*" until the resulting transaction is assembled. When transaction is assembled, TAssembler is " *not Ready to Receive*" and "*Ready to Give*".

Properties

```
property Capacity: longint;
```

Sets the number of the input transactions needed to obtain the assembled transaction.

Methods

```
function IsReadyToReceive(Trans: TTransaction): boolean;
```

See 3.3. TBlock

Events

```
property OnEnter: TOnEnterToBlock;
```

See 3.3. TBlock

```
property OnExit: TOnExitFromBlock;
```

See 3.3. TBlock

```
property OnRouting: TOnRoutingEvent;
```

See 3.3. Tblock

4.14. TCreator

Declaration

```
TCreator = class(TBlock)
```

Purpose

Creates the transactions on demand. After creation of transactions the component is *"Ready to Give*" as long as transactions are being emitted. In a combination with *TScheduler* you can simulate the generator, which produces portions of the transactions.

Methods

```
procedure Generate(Number: longint);
```

Immediately generates *Number* transactions and order the next activation time equal to 0. Thus, after the generation simulation manager immediately tries to move generated transactions through the model.

Events

```
property OnAfterGeneration: TonAfterGenerationEvent;
```

The event occurs right after generation of transaction. It's a good time to set the transaction properties like priority, preemptive property or fields defined by user. (See 3.4. TGenerator.)

```
property OnExit: TOnExitFromBlock;
```

See 3.3. TBlock

```
property OnRouting: TOnRoutingEvent;
```

See 3.3. TBlock

4.15. TGate

Declaration

```
TGate = class(TBlock)
```

Purpose

This block is a simple gate. You can lock, unlock and inverse the gate. If gate is unlocked it works like simple server with zero service time. By locking the gate you discontinue promoting of the transactions that go through it.

Methods

```
procedure Inverse
```

Locks the gate if it is unlocked and vice-verse.

```
function IsLocked: boolean;
```

Returns *True* if the gate is locked and vice -verse.

```
procedure Lock;
```

Sets the gate into the " *not Ready to Receive*" state. If there is transaction in the gate in the locking moment, this transaction will leave the gate whenever it will be possible.

```
procedure Unlock;
```

Unlocks the gate.

Events

```
property OnEnter: TOnEnterToBlock;
```

See 3.3. TBlock

```
property OnExit: TOnExitFromBlock;
```

See 3.3. TBlock

```
property OnRouting: TOnRoutingEvent;
```

See 3.3. Tblock

4.16. TTabulator

Declaration

```
TTabulator = class(TComponent)
```

Purpose

This component is not an aggregate. It is designed for statistical purposes only. If you need to build histogram of some output parameter, this component helps you to calculate the hits of its values in numerical intervals. Beside that, *TTabulator* calculates the average value of the parameter and its standard deviation.

Properties

```
property Interval: real;
```

Width of a numerical interval.

```
property IntervalCount: byte;
```

Number of intervals. The range of admissible values is from 2 to 254.

```
property LowerBound: real;
```

Lower bound of the first interval.

Methods

```
function Count: longint;
```

Returns the total number of tabulated values.

```
function Deviation: real;
```

Returns the standard deviation of tabulated values.

```
function Hits(Index: byte): longint;
```

Returns the number of hits in *Index* interval. If *Index* is equal to 0, the function returns the number of hits lower than *LowerBound*. If *Index* is equal to *IntervalCount+1,* the function returns the number of hits higher than the upper bound of the last interval.

```
function Mean: real;
```

Returns the average value of tabulated values.

```
procedure PutValue(Value: real);
```

Inputs value for tabulation.

```
procedure Resets;
```

Resets all accumulated data.

4.17. TMultiRand

Declaration

```
TMultiRand = class(TComponent)
```

Purpose

This component is intended to generate random values of different distributions.

Properties

The basement for obtaining all distributions is uniform distribution from 0 to 1. The prime modulus multiplicative congruent random number generator (PMMCG) is used to obtain uniformly distributed values. The algorithm of PMMCG is the following.

```
MODULUS: = 2147483647;      // 2^31-1
Seed:=(Multiplier * Seed) mod MODULUS;
Result:=Seed / MODULUS;
```

```
property Seed: comp;
```

This property sets the initial seed for PMMCG. The value of *Seed* should be in the range from 2 to 2147483646. The default value is 1000000000.

```
property Multiplier: comp;
```

This property sets the multiplier for PMMCG. The value o f *Multiplier* should be in the range from 2 to 2147483646. The default value is 950706376.

Fishman and Moore (1986) recommended the following best values of *Multiplier*.

950,706,376
742,938,285
1,226,874,159
62,089,911
1,343,714,438

Methods

```
function Beta(ShapeAlpha: real; ShapeBeta: real;
              LowerBound: real; UpperBound: real): real;
```

Returns Beta distributed values with the following parameters and limitations:

ShapeAlpha – α-shape, *ShapeAlpha* > 0;
ShapeBeta – β-shape, *LowerBound* > 0;
LowerBound – Lower bound of distribution, *LowerBound* >= 0;
UpperBound – Upper bound of distribution, *UpperBound* > 0, *LowerBound* <= *UpperBound.*

Method: Transformation of random values where sample from Beta distribution is some ratio of two Gamma-distributed samples [4].

```
function Gamma(Mean: real; Alpha: real): real;
```

Returns Gamma-distributed variants.

Mean – the mean of distribution, *Mean* >= 0;
Alpha – the α-shape parameter, *Alpha* > 0.

Method: For α<1, Jonk's method is used [7]. For α>1 the function uses combination of Gamma distribution for α<1 and Erlang distribution.

```
function Erlang(Mean: real; M: integer): real;
```

Returns values with Erlang distribution. Distribution has the following parameters.

Mean – the mean of distribution, *Mean* >= 0;
M – the shape parameter, *M* > 0.

Method: Summarizing M exponential values; each of them is exponentially distributed with the mean equal to *Mean/M* [7].

```
function Exponential(Mean: real): real;
```

Returns exponentially distributed values with the mean *Mean,* where *Mean* >= 0.

Method: Inverse transfomation [7].

```
function Lognormal(Mean: real; Deviation: real): real;
```

Returns variants with lognormal distribution. *Mean* and *Deviation* parameters are the mean and standard deviation of the distribution; both parameters should be greater than 0.

Method: For the equation *L=exp(N)*, if *N* is normal distributed variants then *L* is lognormal distributed [2].

```
function Normal(Mean: real; Deviation: real): real;
```

Returns variants with normal distribution. The mean and standard deviation of the variants are set in the parameters *Mean* and *Deviation*; both parameters should be greater than 0.

Method: Transformation of random variables with a selective truncation was used for obtaining normal variants [1,3].

```
procedure Reset;
```

Resets the component into initial state. It sets *Seed* into initially assigned value and resets some internal triggers.

```
function Triangular(Min: real; Mode: real; Max: real): real;
```

Returns values with triangular distribution. Distribution has the following parameters.

Min – minimal value, *Min* >= 0.0;
Max – maximal value, *Max* >= 0.0;
Mode – mode of distribution, *Mode* >= 0.0, *Min* <= *Mode* <=*Max*.

Method: Inverse transformation [6].

```
function Uniform(LowerBound: real; UpperBound: real): real;
```

Returns values uniformly distributed between *LowerBound* and *UpperBound.* Both parameters should be equal or greater than 0 and *LowerBound* <= *UpperBound*.

```
function Weibull(Alpha: real; Scale: real): real;
```

Returns values with Weibull distribution, which has the following parameters.

Alpha – shape, *Alpha* > 0
Scale – scale, *Scale* > 0

Method: Inverse transfomation [5].

References

1. Ahrens, J.H. and U.Dieter, "Computer Methods for Sampling from the Exponential and Normal Distributions", *Comm. ACM*, Vol. 15, 1972, pp. 873-882.
2. Aitchison, J. and J.A.C. Brown, *The Lognormal Distribution*, Cambridge Press, 1957
3. Box, G.E.P. and M.A.Miller, "A Note on the Generation of Random Normal Deviates", *Annals of Math Stat.*, Vol. 29, 1958, pp. 610-611.
4. Fishman, G.S., *Principles of Discrete Event Simulation*, John Wiley, 1978.
5. Hahn, G.J. and S .S.Shapiro, *Statistical Models in Engineering*, John Wiley, 1967
6. Pritsker, A.A.B., *The GASP IV Simulation Language*, John Wiley, 1974
7. Pritsker, A.A.B., *Introduction to simulation and SLAM II*, John Wiley, 1984