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Introducing Messages in Modelica for Facilitating Discrete-Event System Modeling

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Outline

- Introduction
- Process-Oriented Modeling
  - ARENALib
  - SIMANLib
- Parallel DEVS
  - DEVSLib
- Messages in Modelica
- Conclusions

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Introduction

- Objective: process-oriented modeling using the Modelica language
- Modelica capacities for discrete-event system modeling
  - *If-expressions*
  - *when-clauses*
- Previous works use event-scheduling
  - State Machines, Petri Nets, DEVS,...

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Introduction

- New Modelica libraries have been developed for process-oriented modeling
  - ARENALib, SIMANLib
- Parallel DEVS formalism has also been considered
  - DEVSLib
- Complex solutions to problems and still some restrictions
- Introduction of the messages mechanism for facilitating discrete-event system modeling
  - Proposed implementation

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Process-Oriented Modeling

- System observed from the point of view of an entity
- Entities flow through the system and are processed using resources. If no resources are available, entities usually wait in queues
- Flow of information between components
- Examples:
  - Bottle manufacturing process
  - Airport check-in system
  - Bank teller

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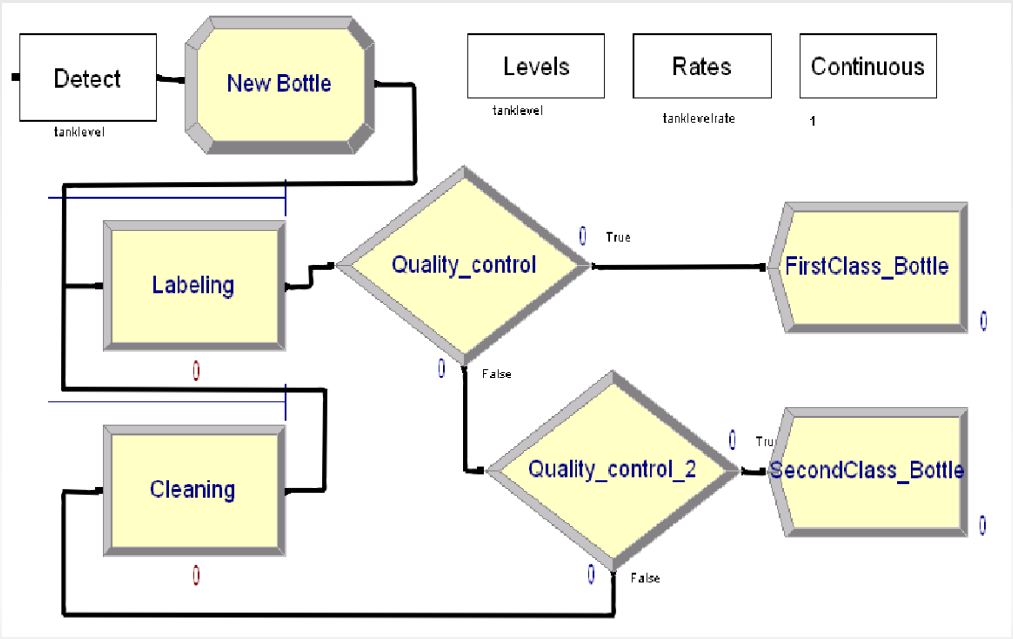
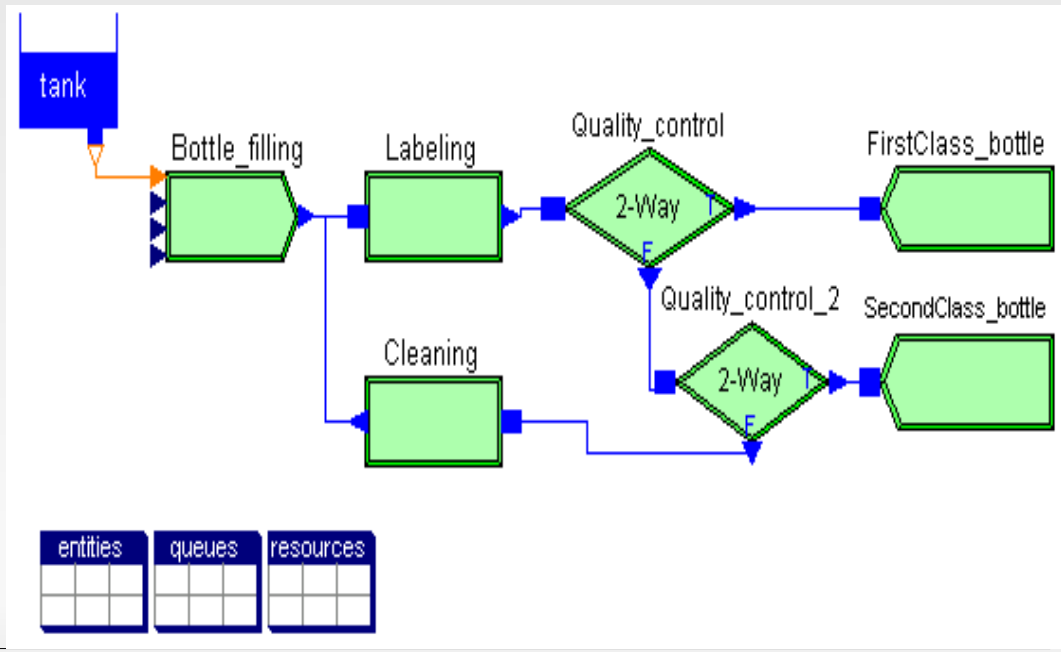
Process-Oriented Modeling

- ARENALib
  - Based on the Arena simulation environment
  - Components: flowchart and data modules
  - Entities are transferred between flowchart modules





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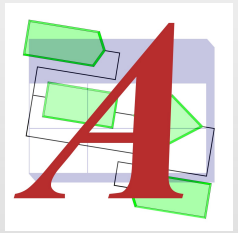
Process-Oriented Modeling

- Model Communication
  - *Direct Transmission*
    - Entities defined with variables inside the connector
    - Problem with the simultaneous reception of entities
      - Semaphores: poor performance
      - *Flow* variable: connector cannot contain several entities at the same time
  - *Text File approach*
    - Text file as intermediate storage for entities
    - Poor performance and low flexibility.



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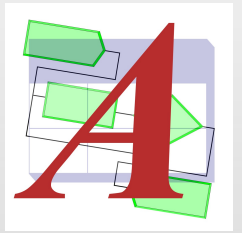
Process-Oriented Modeling



- Model Communication (II)
  - *Dynamic Memory Storage*
    - Substitute the text file with dynamic memory space
    - Increases performace
    - Higher flexibility due to independency between data structures and their management
- Entity Management
  - Temporal storage for delayed entities.
  - Use of dynamic memory storage.

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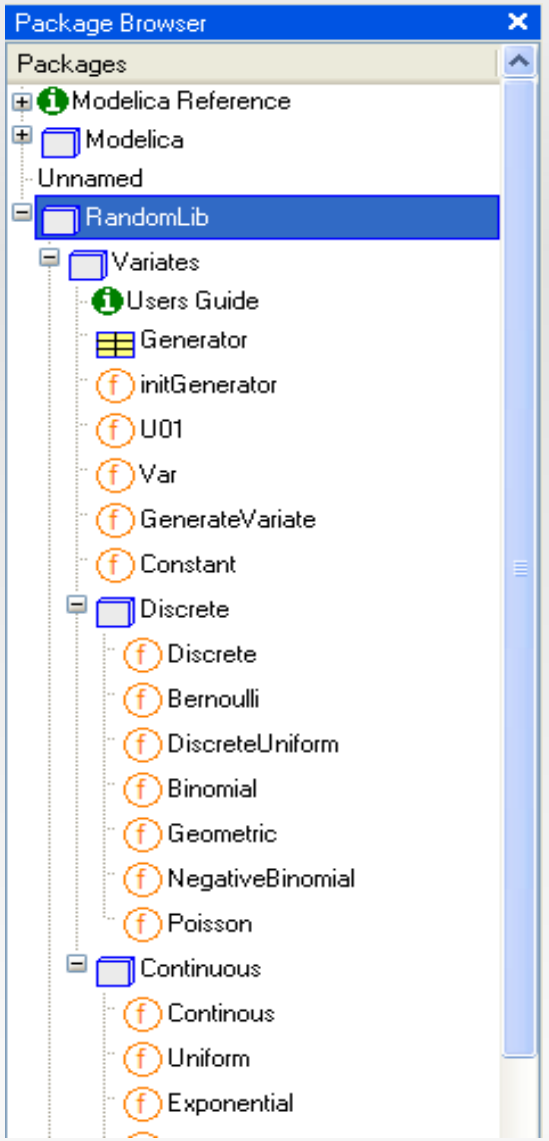
Process-Oriented Modeling

- Stochastic Data Generation
  - CMRG and RandomLib
- Statistical Information Management
  - Statistical indicators.

Module	Indicator	Values
Create	System.NumberIn	Obs
Process	NumberIn	Obs
	NumberOut	Obs
	VATime Per Entity	Avg, Min, Max, Final, Obs
	NVATime Per Entity	Avg, Min, Max, Final, Obs
	TotalTime Per Entity	Avg, Min, Max, Final, Obs
	Queue.NQ	Avg, Min, Max, Final
	Queue.WaitTime	Avg, Min, Max, Final, Obs
Dispose	System.NumberOut	Obs
EntityType	NumberIn	Obs
	NumberOut	Obs
	VATime	Avg, Min, Max, Final, Obs
	NVATime	Avg, Min, Max, Final, Obs
	TranTime	Avg, Min, Max, Final, Obs
	WaitTime	Avg, Min, Max, Final, Obs
	OtherTime	Avg, Min, Max, Final, Obs
	Work In Progress	Avg, Min, Max, Final



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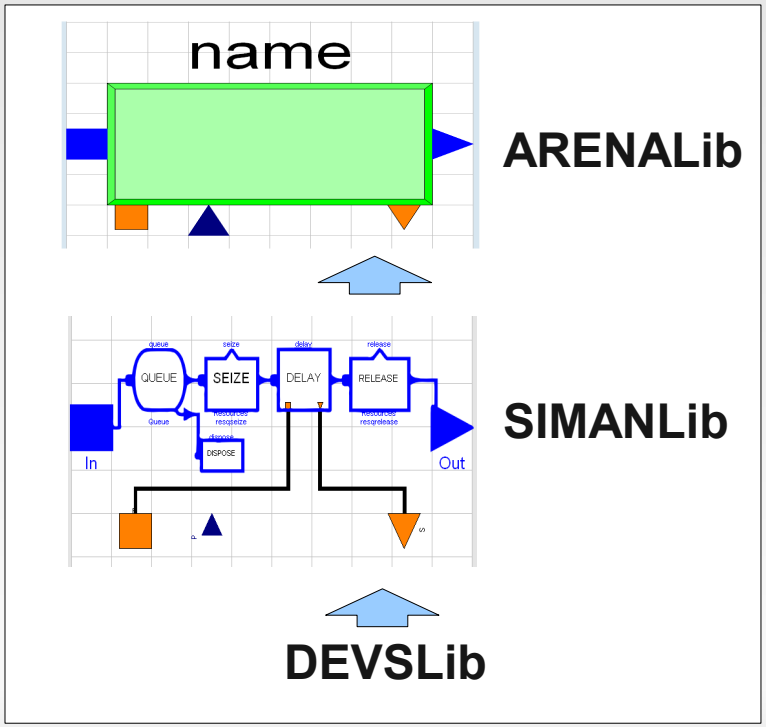
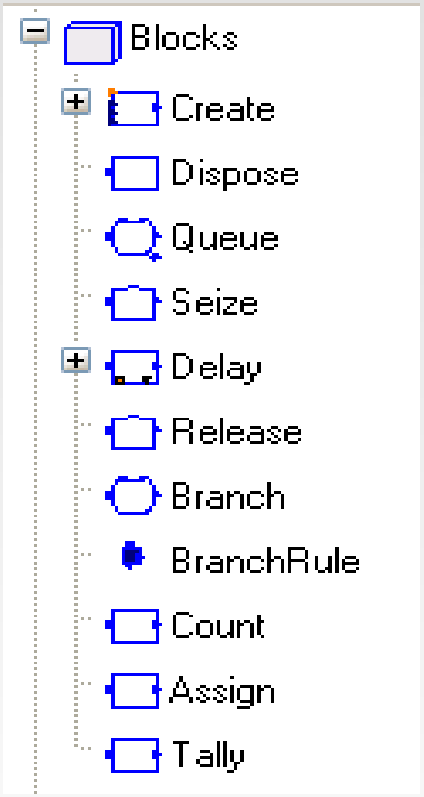
Process-Oriented Modeling

- SIMANLib
  - Reproduces some basic functionalities of the SIMAN simulation language
  - Components: blocks and elements





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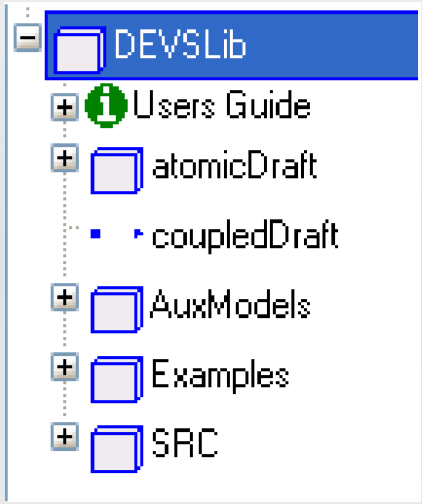
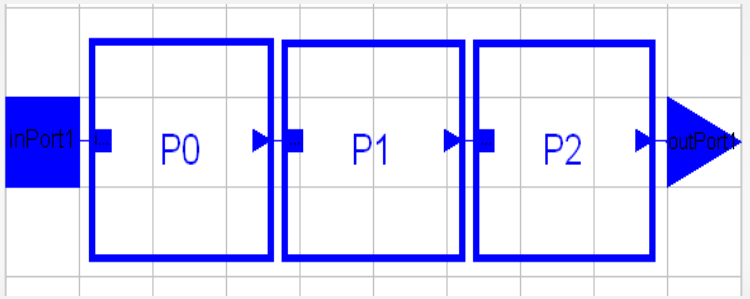
Parallel DEVS

- DEVSLib
  - Library Architecture
  - Model Development
    - Atomic model
      1. Duplicate atomicDraft
      2. Include input and output ports
      3. Redeclare fext, fint, fout, ta, initst and st
    - Coupled model
      1. Include input and output ports
      2. Include components (atomic or coupled models)
      3. Connect components




```
model processor
  extends AtomicDEVS(
                redeclare record State = st);
  redeclare function Fcon = con;
  redeclare function Fint = int;
  redeclare function Fext = ext;
  redeclare function Fta = ta;
  redeclare function initState =
                initst(dt=processTime);
  parameter Real processTime = 1;

  Interfaces.outPortManager
                outPortManager1(n=1,
                redeclare record State = st,
                redeclare function Fout = out);
  Interfaces.outPort outPort1; // output port
  Interfaces.inPort inPort1; // input port
equation
  iEvent[1] = inPort1.event;
  iQueue[1] = inPort1.queue;
  connect(outPortManager1.port,outPort1);
end processor;
```



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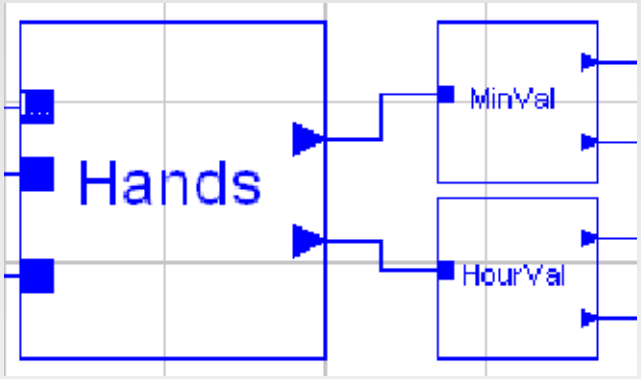
Parallel DEVS

- Modeling Restrictions
  - One-to-Many connections. DUP model.



  - Static information structure transmitted at events
    - Current: type and value
    - Additional types: arrays, records,...

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Messages in Modelica

- Simple mechanism for communicating information between models
- Components: message and mailbox
- Characteristics
  - Messages can be sent to any available mailbox
  - Mailboxes warn of new incoming messages
  - Messages are read from the mailbox
  - Tranmission of messages is intantaneous.
  - Content of the message independent from its type
  - Messages can be received simultaneously
  - Two stages in the communication: send and reception

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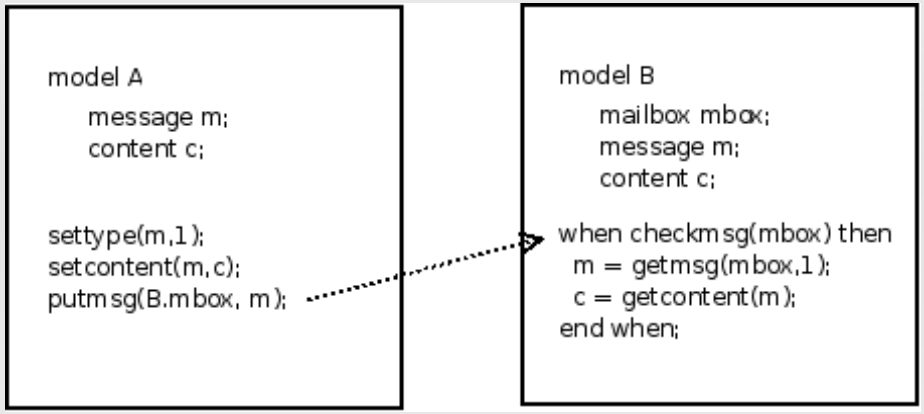
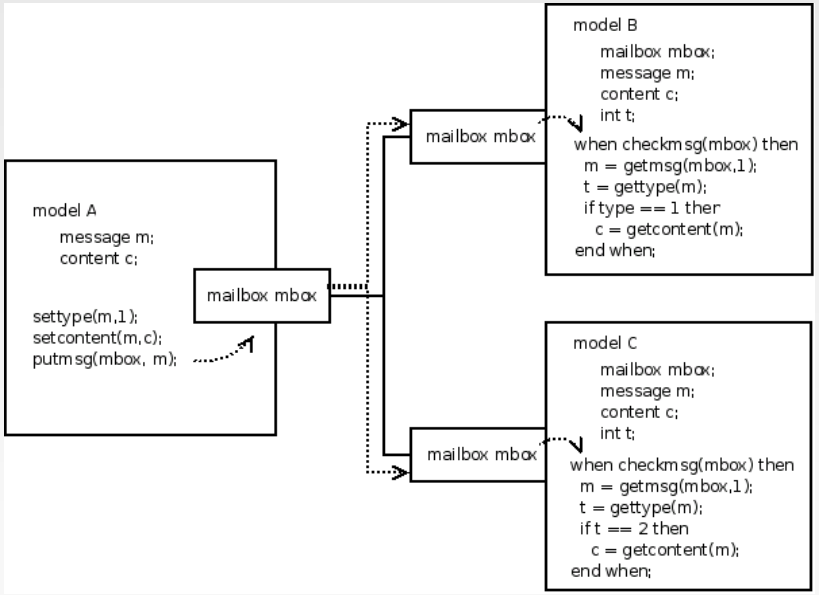
Messages in Modelica

- Communication using messages



  - Mailboxes can be shared between models
  - Mailboxes can be included in connectors
  - The user has to define the treatment of each message



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Messages in Modelica

- Proposed Implementation
  - Data Structures
    - Message: type and reference to the content
    - Mailbox: reference to temporary storage space
  - Operations.
    - Mailbox operations
      - Newmailbox, checkmsg, newmsg, nummsg, readmsg, getmsg, putmsg
    - Message operations
      - Newmsg, gettype, settype, getcontent, setcontent

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Conclusions

- Process-oriented modeling with Modelica is a difficult task
- Several Modelica libraries have been developed for process-oriented modeling.
- Its implementation present problems and restrictions, and the applied solutions are complex
- Messages mechanism facilitates the transmission of information between models
- Messages simplify the development of discrete-event system models

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