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MATLAB&SIMULINK®

Modeling Complex Systems Using SimEvents

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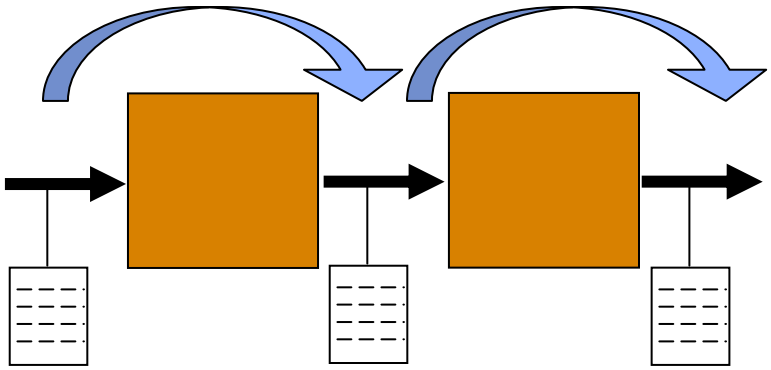
Topics

- Discrete Event Simulation
- SimEvents Components
- System Example

What is SimEvents?

- SimEvents provides a natural, efficient way of modeling systems that are *activity-based* versus systems that are purely continuous-time based
  - Systems can be modeled at the transaction level
  - Model semantics are primarily activity- or event-based
  - Untimed means no explicit notion of time is needed
- SimEvents adds Discrete Event Modeling (DES) to Simulink®
  - DES and continuous time are integrated

SimEvents Model



Modeling A Hybrid System: Golf!

When do you tee off?

Discrete event:
- Tee is available
- You tee off

SimEvents

"If…
or if…
or if…"

Control logic and FSM:
- Situation determines action
- Club selection

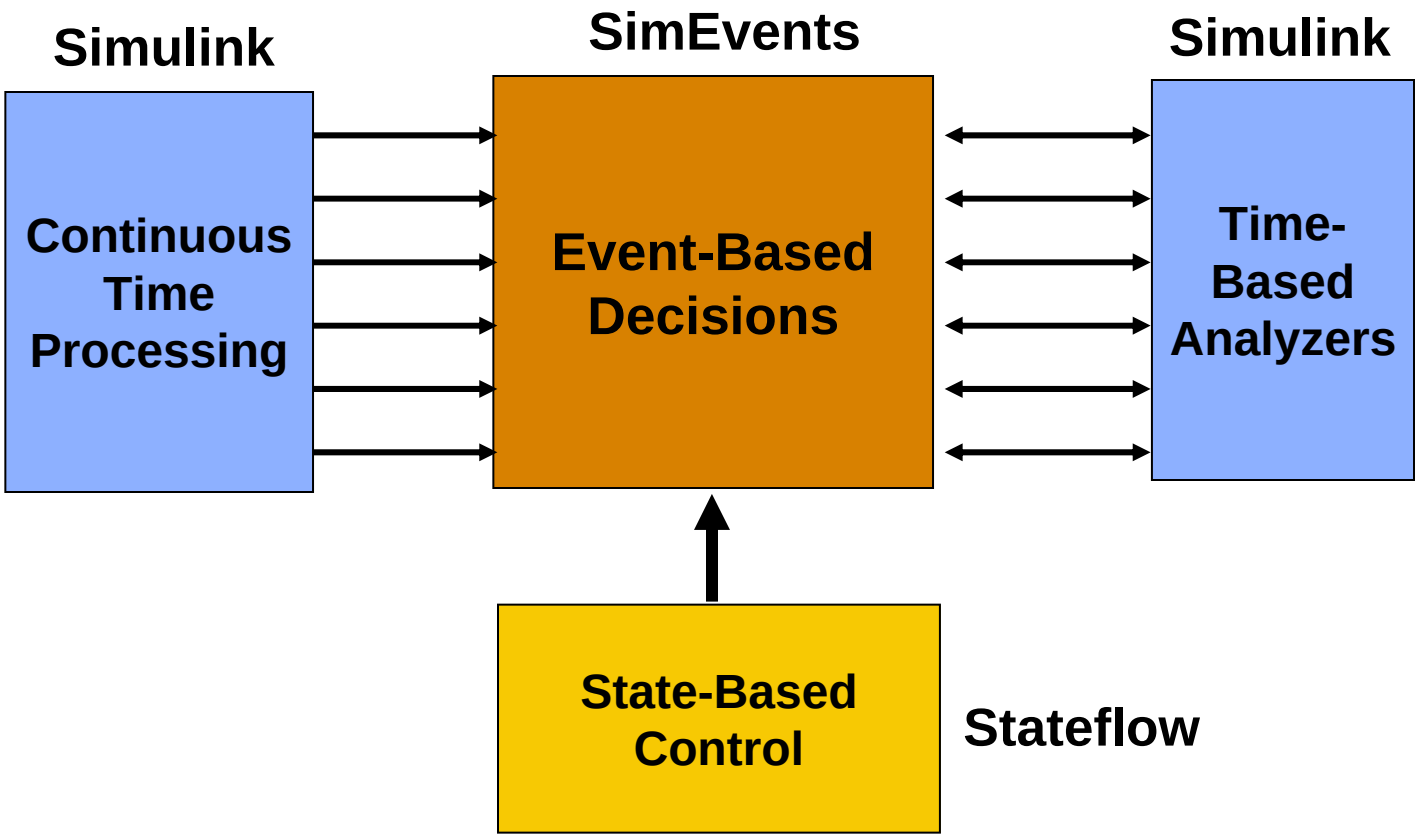
Stateflow®

$Y=v_0t + \frac{1}{2}gt^2$

Time-driven dynamics:
Trajectory of the ball

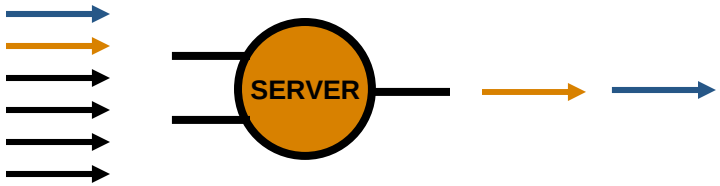
Simulink®

Hybrid System: Communication System

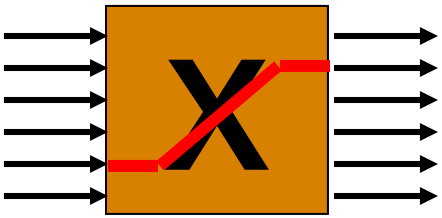


What does SimEvents give you?

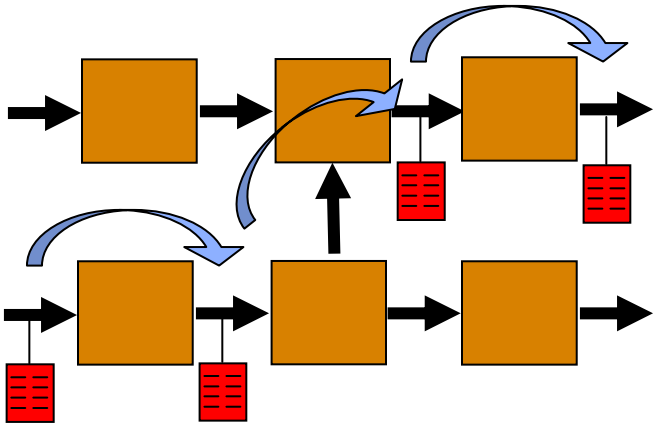
- Model systems requiring access to a shared resource



- Model systems that selectively route data and items through blocks

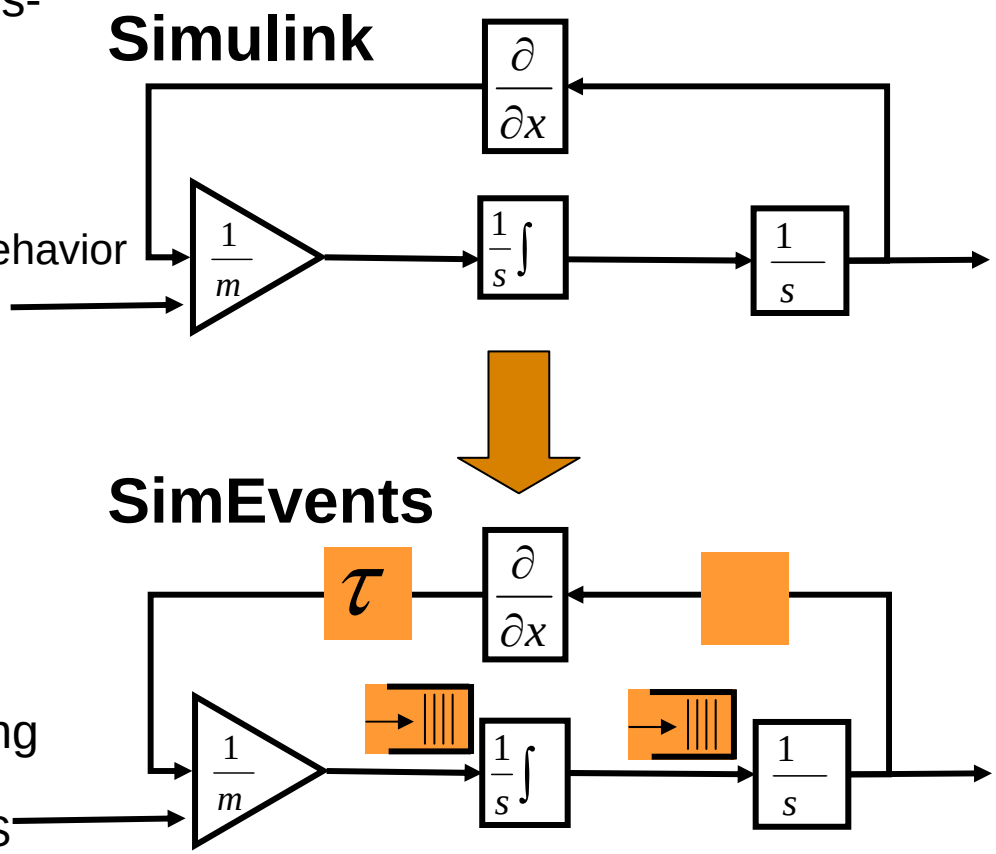


- Model systems that are activity-based rather than time-based



What is the relationship with Simulink?

- SimEvents transforms a continuous-time model in Simulink
  - WITH
- Addition of elements to model:
  - Asynchronous or discrete event behavior
  - Delays
  - Queuing
  - Routing
  - Priority and preemption
- To more accurately model non-continuous time systems behavior under real world conditions
- Model is not restricted to processing data in a serial fashion
  - Interrupting processes in an RTOS



What is the value of SimEvents?

Model is adapted to the level of complexity required!

Engineering Roles

- System Architect
  - Analyzes system features and applications before committing to a final choice
- System Engineer
  - Models system features and applications mapped onto a selected implementation
- Module Developer
  - Verifies that module(s) deliver the required feature subset while meeting performance requirements imposed by the rest of the system

Roles with SimEvents

- System Architect
  - Models system functions without having to worry about detailed timing
- System Engineer
  - Evaluates the robustness of the chosen implementation:
    - Timing
    - Discrete event behavior
    - With other implementation details
- Module Developer
  - Verifies module behavior and performance in the presence of real world uncertainties associated with
    - Timing
    - Non-periodic or discrete behavior
    - System loading

Typical Applications

- Mission planning
- Logistics
- Packet-based communications
- Base station access
- RTOS modeling
- Supervisory and distributed control
- Manufacturing systems
- Service scheduling
- Etc.

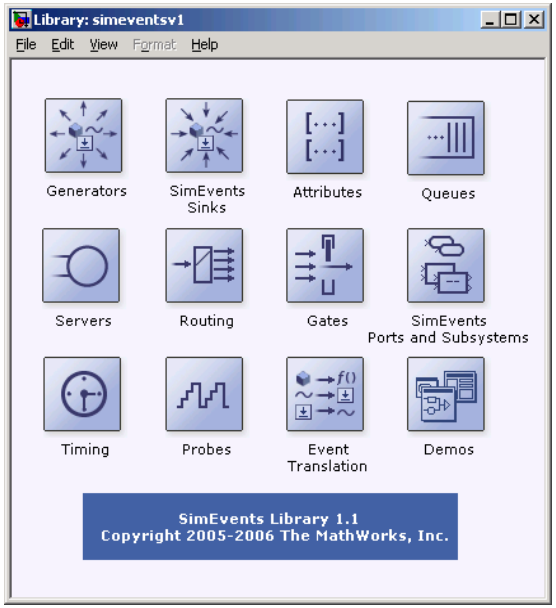
SimEvents Key Features

- Libraries
  - Queues
  - Servers
  - Switches
  - Gates
- Generators
  - Entities
  - Events
  - Signals
- Automatic statistics gathering
  - Delay
  - Throughput

- Enables evaluating a system with a given set of delay and throughput conditions
- Statistic gathering simplifies locating bottlenecks in the system
- Supports hybrid simulation of models containing event-based and time-based execution components

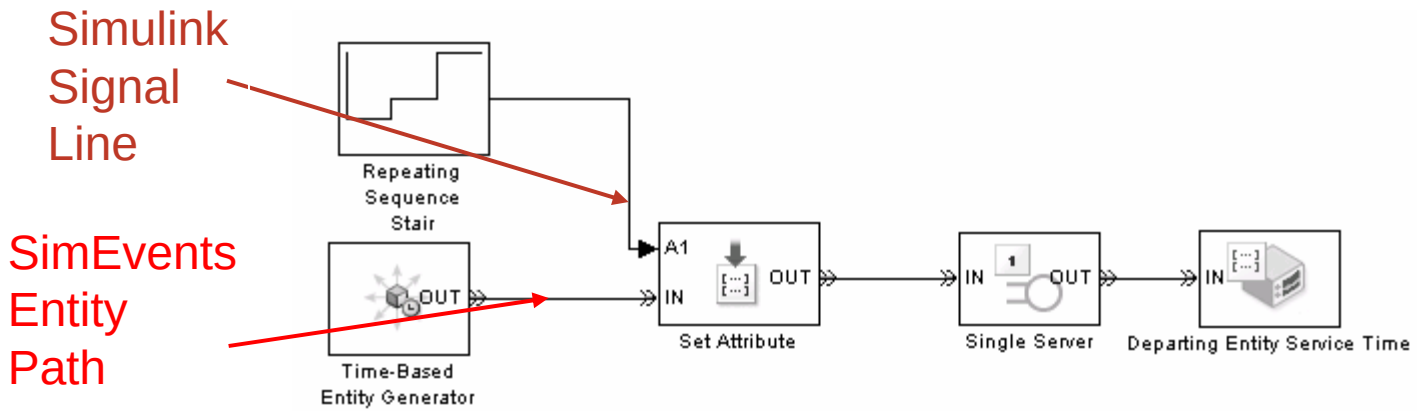
SimEvents Components

- Entities and attributes
- Queues and servers
- Routing entities
- Accessing statistics
- Interfaces with Simulink and Stateflow



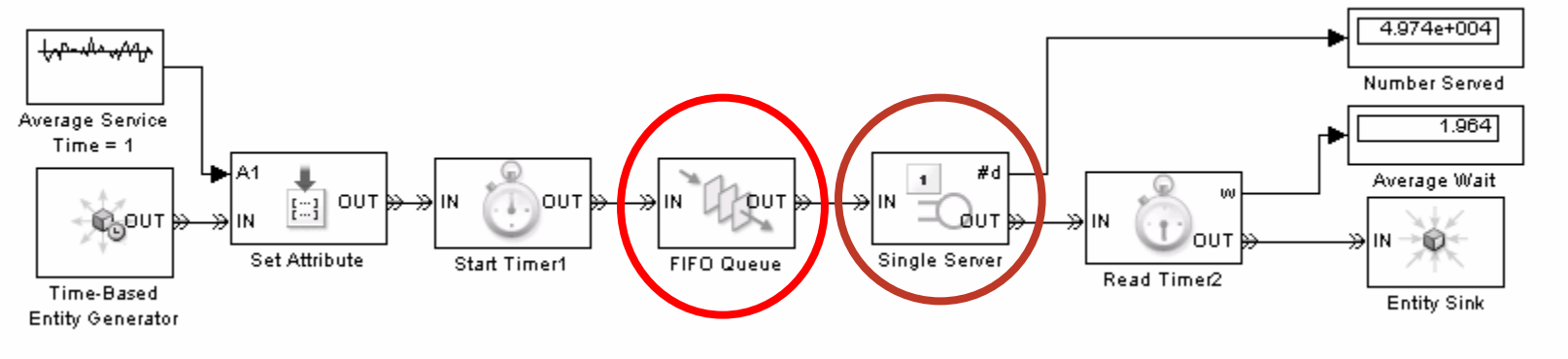
Entities and Attributes

- Entities
  - Abstraction of something in the simulation (i.e., packet or a token)
  - Move through queues, servers, gates, and switches
- Attributes
  - Data carried by entities (i.e., length, dest. address)
  - Model a range of vertical applications



Queues and Servers

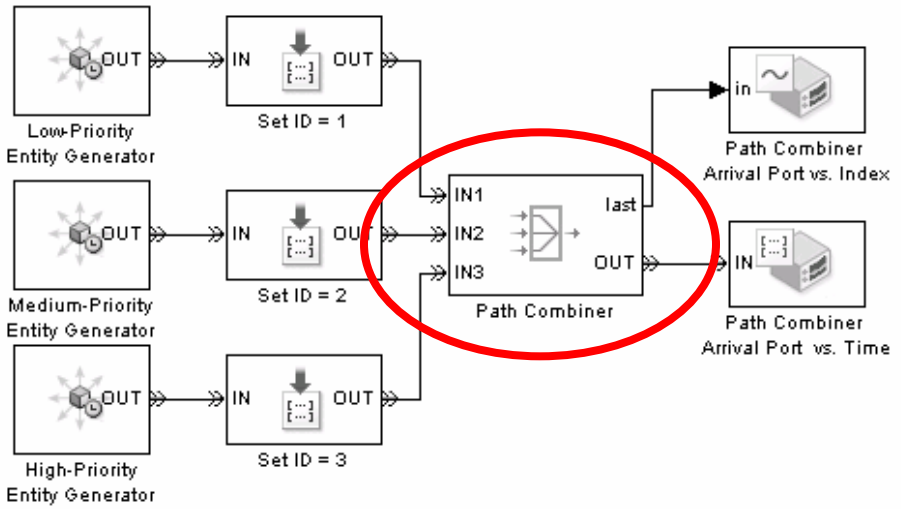
- Queue/Server pair creates delays and storage locations for entities
  - Setting service time of server enables you to model bank teller, machine, packet delay
  - Setting capacity of queue enables you to model waiting in lines, buffers, packet storage
- Blocking: Entities advance *only* when there is a place to go
- Event Priorities: Control of execution order of simultaneous events



Routing Entities

Various network topologies can be created:

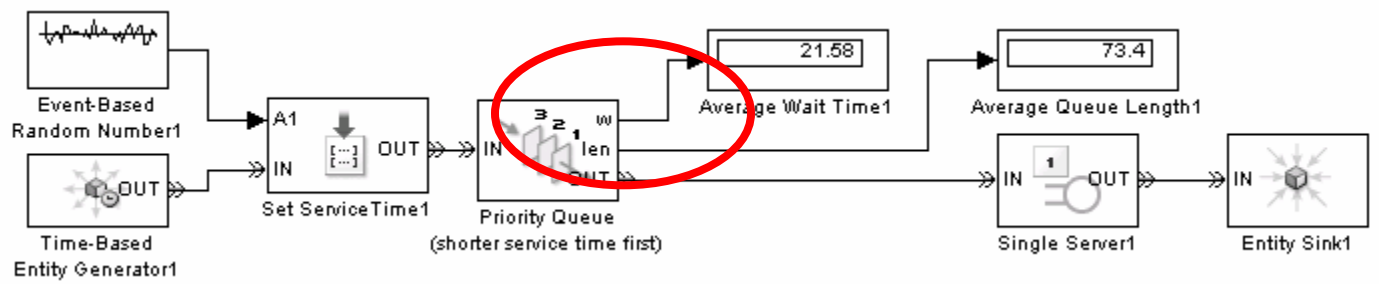
- Merge entity paths
- Select entity from input path
- Select output path for entity
- Replicating entities



Statistics Library

Statistics and block state can be accessed through various blocks by means of output signal ports:

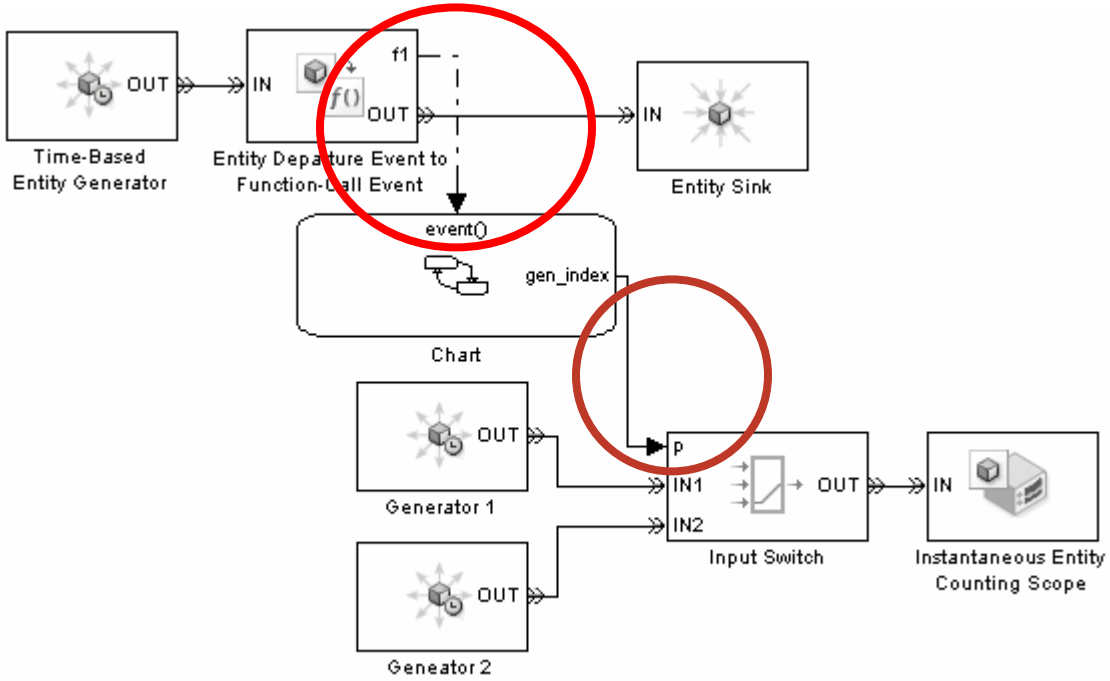
- Entities departed
- Entities in block
- Entity delay and average delay
- Utilization
- Pending entity (blocking status)
- Timer blocks – end-to-end delays
- Number of events



Interfacing with Simulink and Stateflow

Function-calls, triggers (and value change) allow interfacing between SimEvents and Simulink and Stateflow:

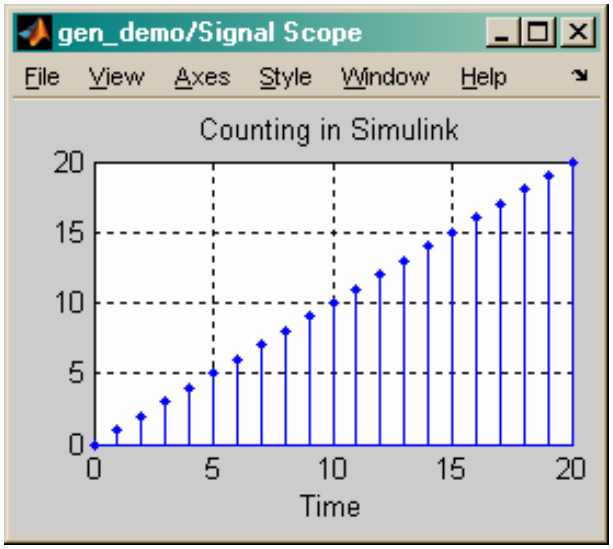
- SimEvents controls StateChart
- StateChart controls SimEvents block



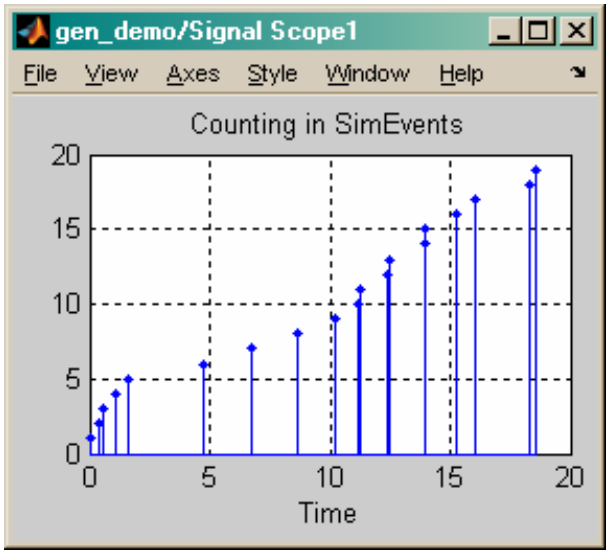
Continuous Time versus Discrete Event

- Simulink – Time advance happens at regular intervals
- SimEvents – Time advance is controlled by the event activity

Simulink Counter

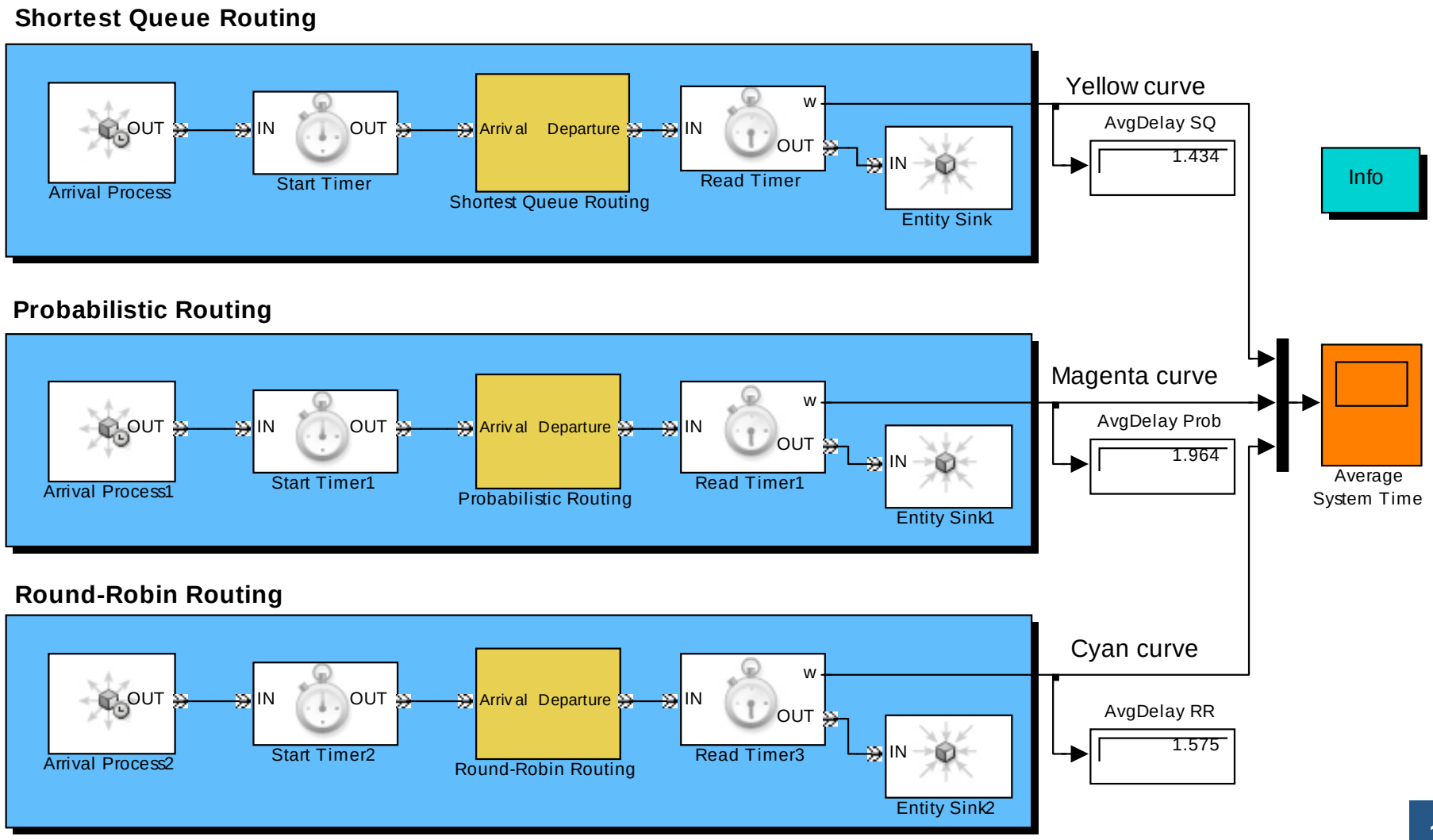


SimEvents Counter

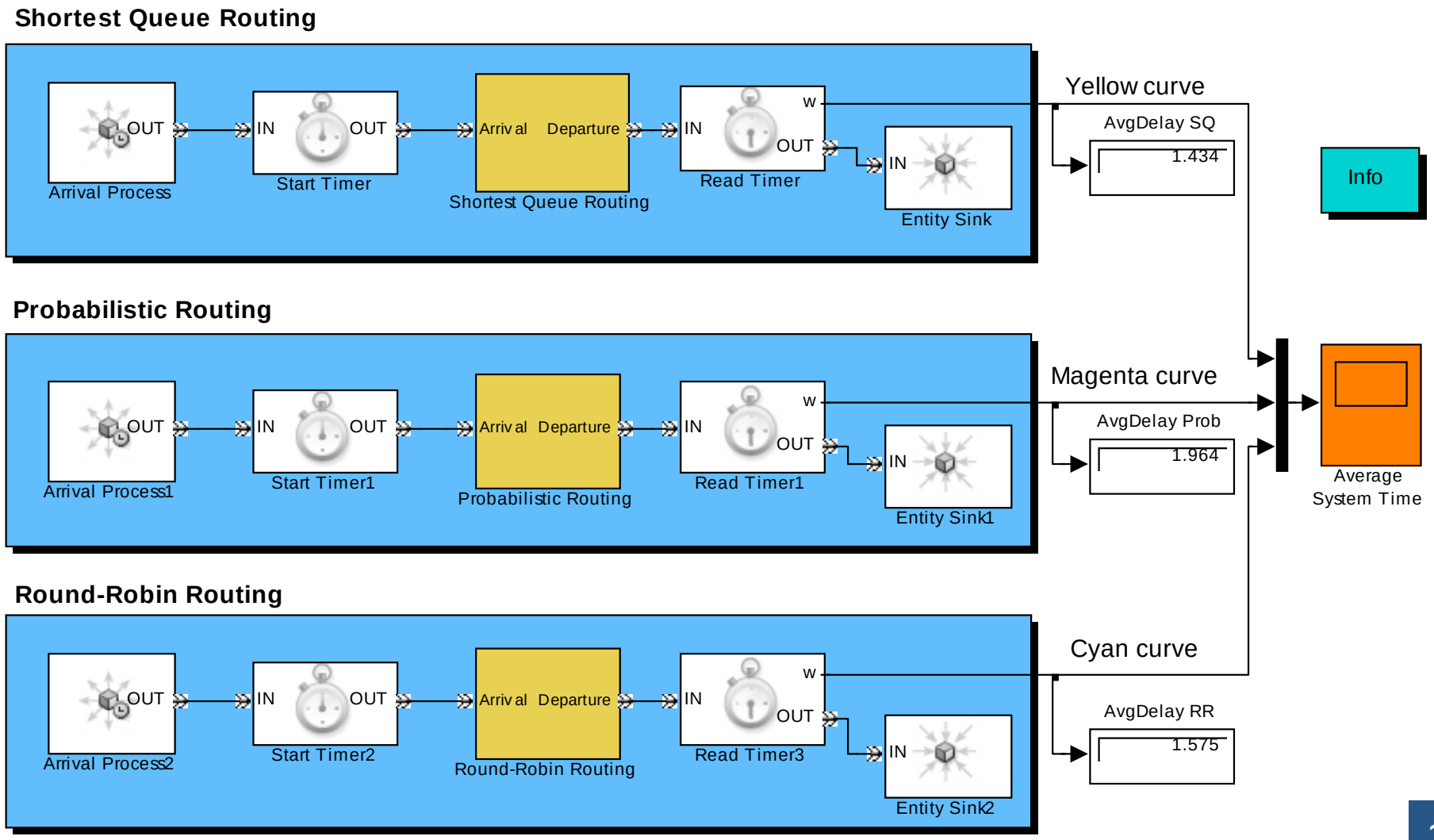


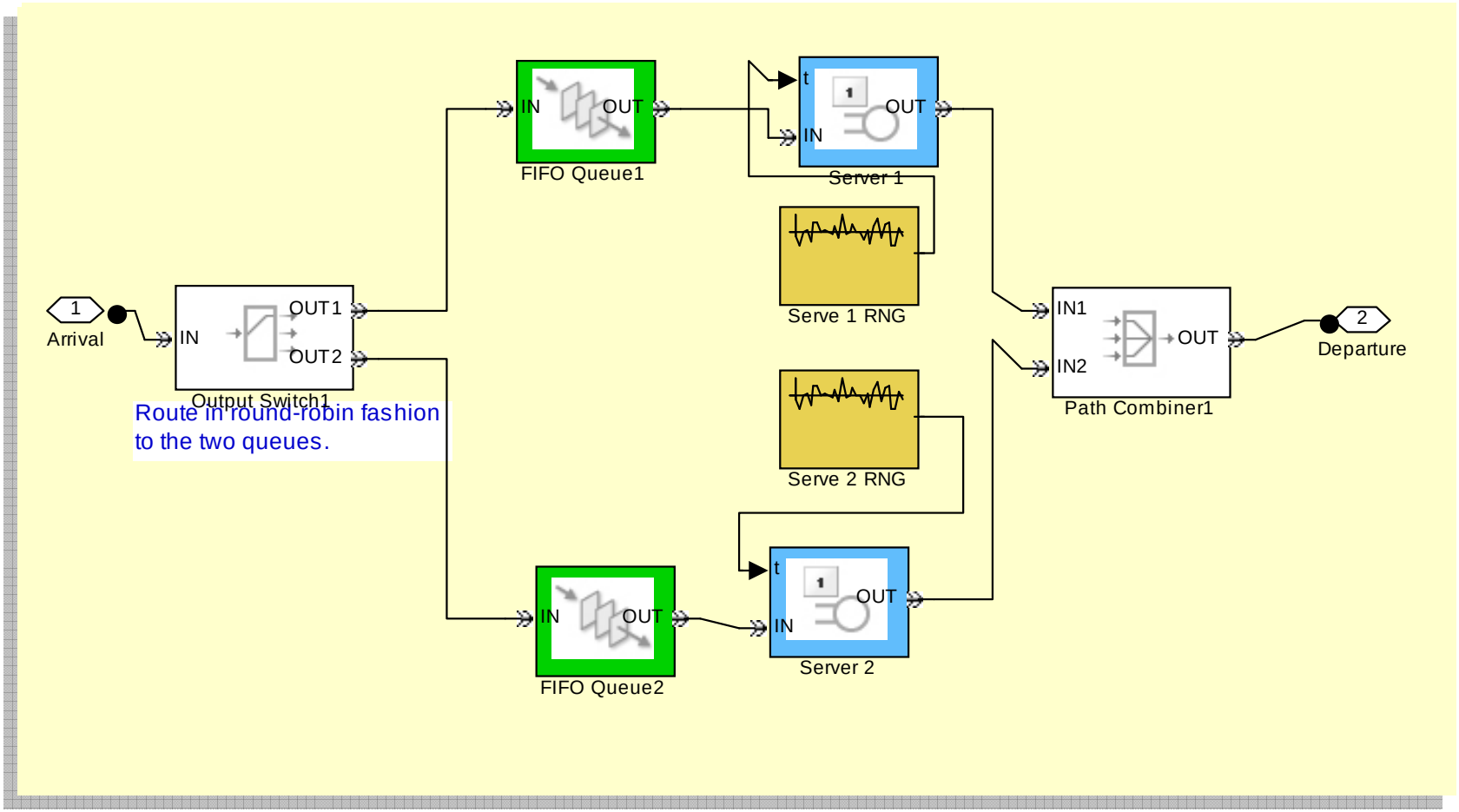
SimEvents provides a more efficient execution flow because blocks are evaluated only when they need to be!

Comparison of Routing Policies

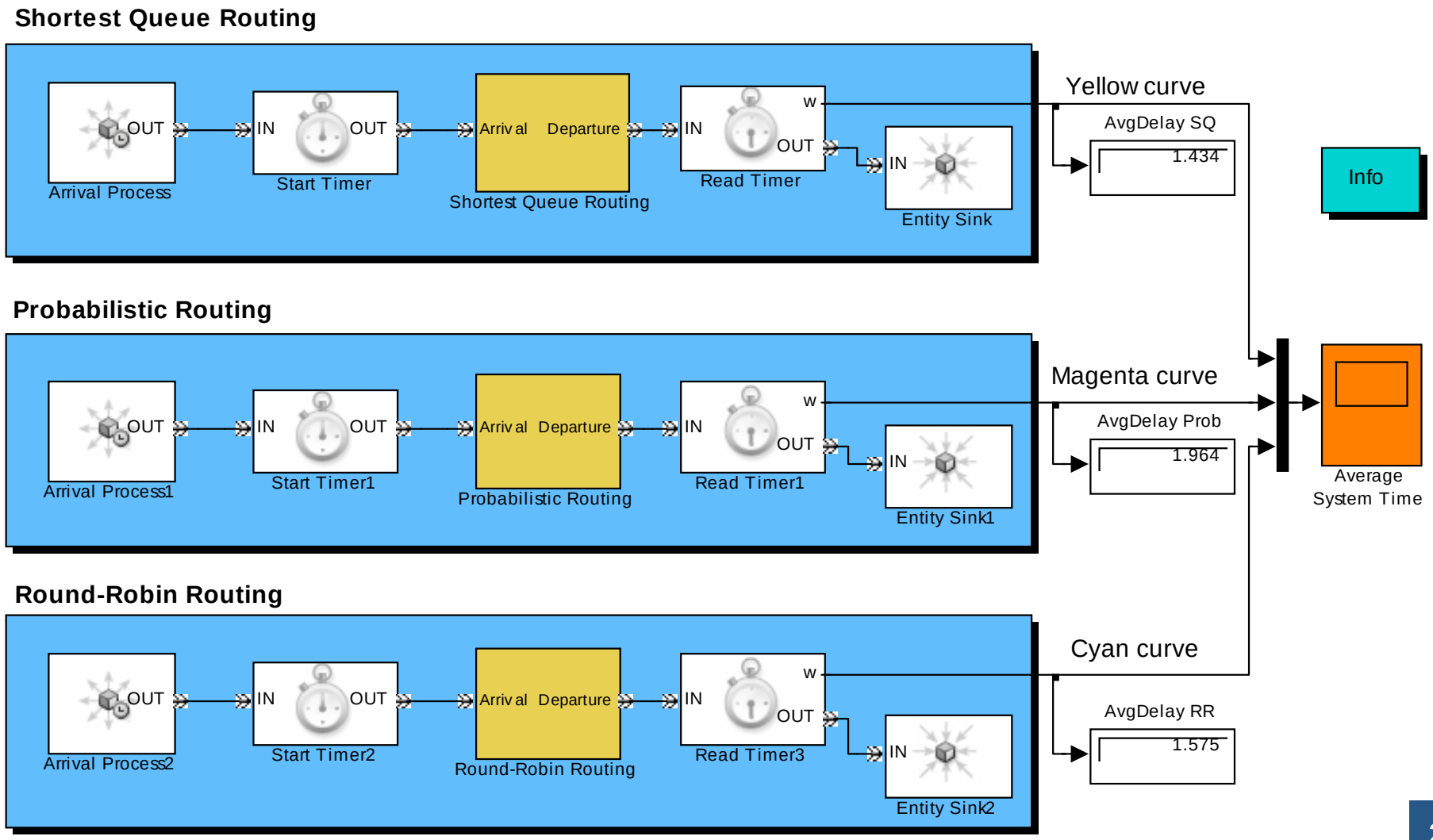


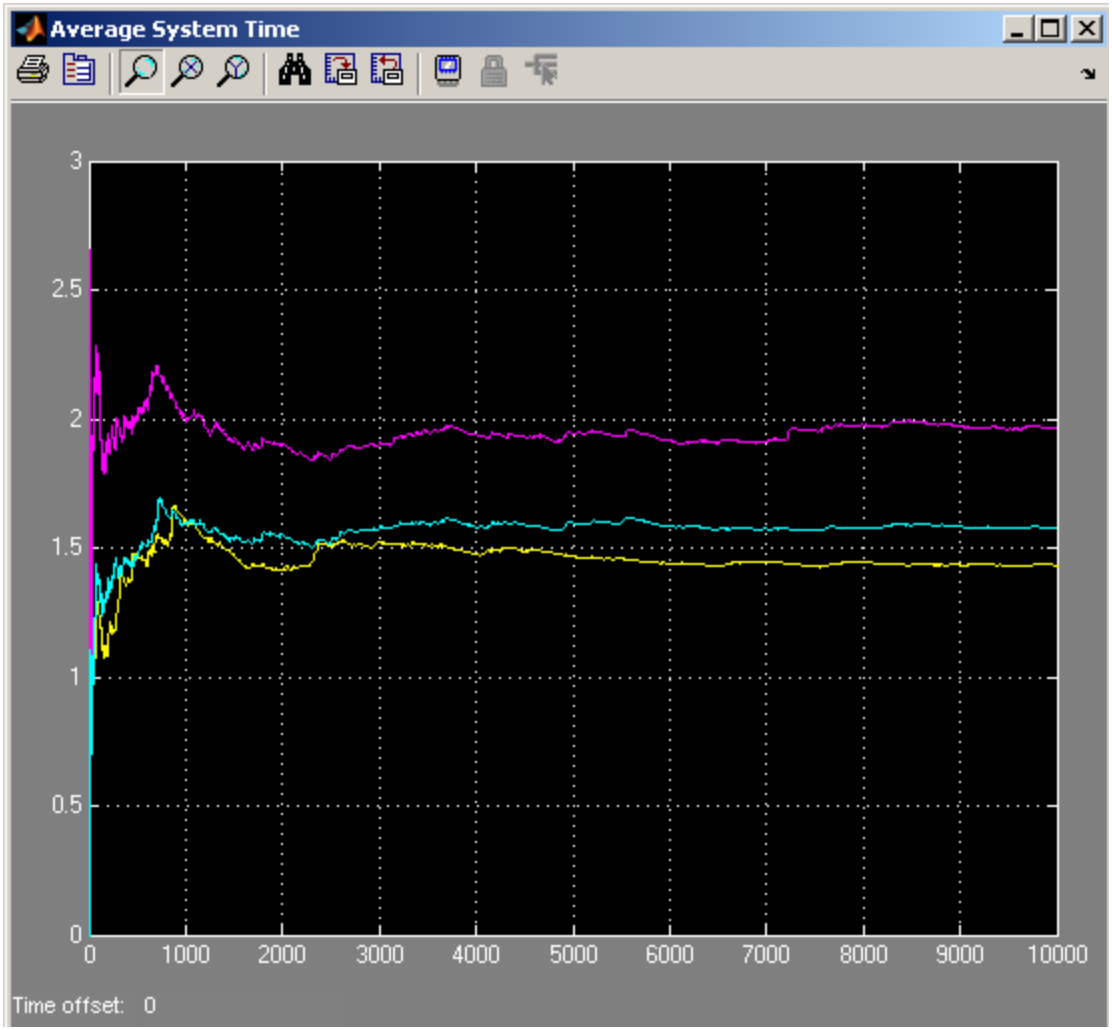
Routing Block




1
Arrival
IN
OUT1
OUT2
Output Switch1
Route in round-robin fashion to the two queues.
IN
OUT
FIFO Queue1
t
1
IN
OUT
Server 1
Serve 1 RNG
Serve 2 RNG
IN
OUT
FIFO Queue2
t
1
IN
OUT
Server 2
IN1
IN2
OUT
Path Combiner1
2
Departure

Comparison of Routing Policies




Average System Time
3
2.5
2
1.5
1
0.5
0
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
Time offset: 0

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