The Parsimony Project: A Distributed Simulation Testbed in Java

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Outline of the Talk

- requirements for distributed discrete-event simulation
- how Java supports distributed discrete-event simulation
- modeling and simulation in Parsimony
- Parsimony simulators
- an example
- conclusions

Requirements for Distributed Discrete-Event Simulation

- modeling support
- dynamic loading
- support for multiple execution threads
- transparent and extensible networking support

How Java Supports Distributed Discrete-Event Simulation

- models as classes, events as runnable objects

- logical processes as threads

- the Java Virtual Machine as simulation engine

- object serialization

- remote method invocation (RMI)

Coupling Event Objects and Model Instances

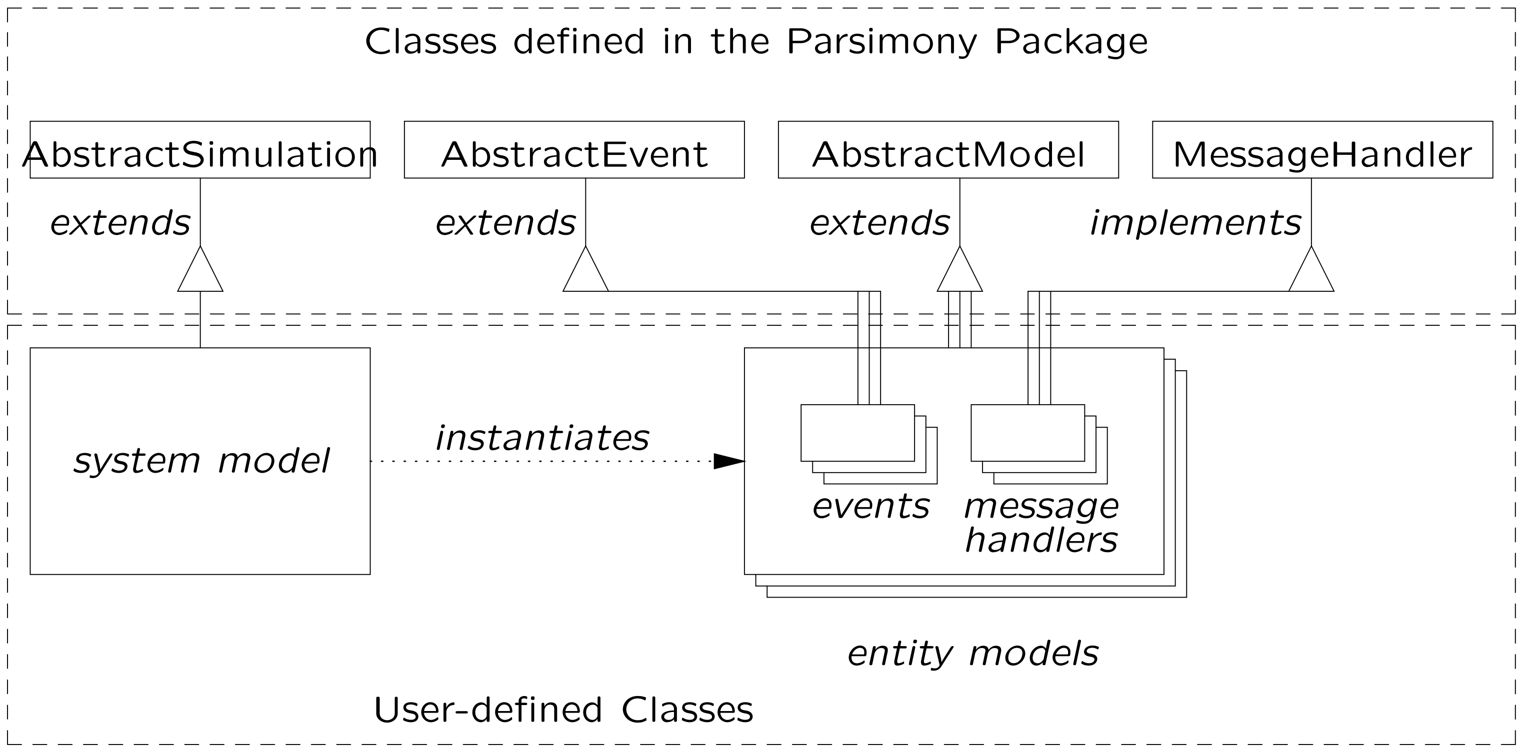
```
class Model
{
   State state = new State();
   class Event implements java.lang.Runnable
   {
      public void run()
      {  modify(state);
         schedule(new Event());
      }
   }
}
```

Modeling and Simulation in Parsimony

- physical processes $\rightarrow$ logical processes
- simulation vs. simulator
- entity models and the system model
- events as run-once runnable objects
- message+handler=event

The Entity Model and System Model Classes

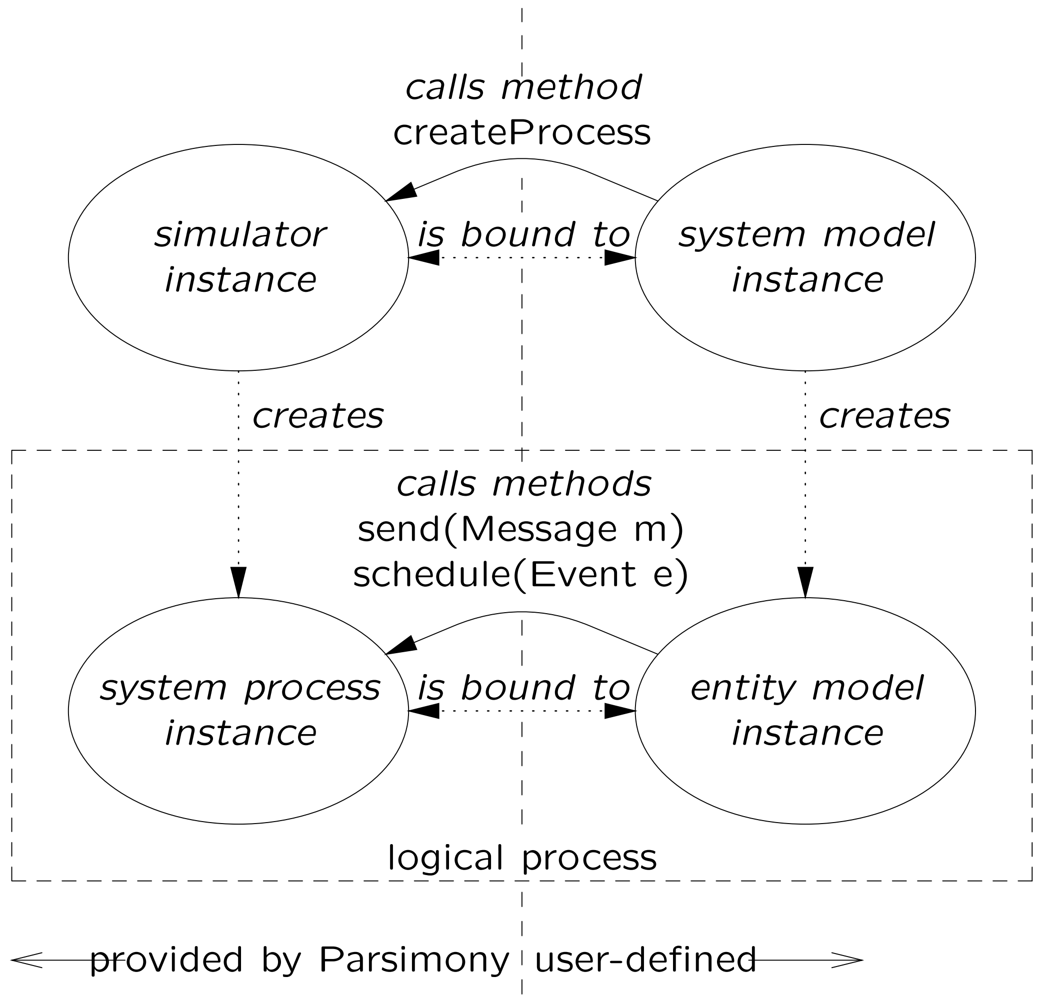
- entity models are derived from `AbstractModel` class
- events are derived from `AbstractEvent` class
- system model is derived from `AbstractSimulation` class
- message handlers implement the `MessageHandler` interface


Classes defined in the Parsimony Package
AbstractSimulation
AbstractEvent
AbstractModel
MessageHandler
extends
extends
extends
implements
system model
instantiates
events
message
handlers
entity models
User-defined Classes

Achieving the Separation of Concerns

- separate user-defined, application-specific simulation code from domain of the simulator

- allow completely transparent support for multiple simulators

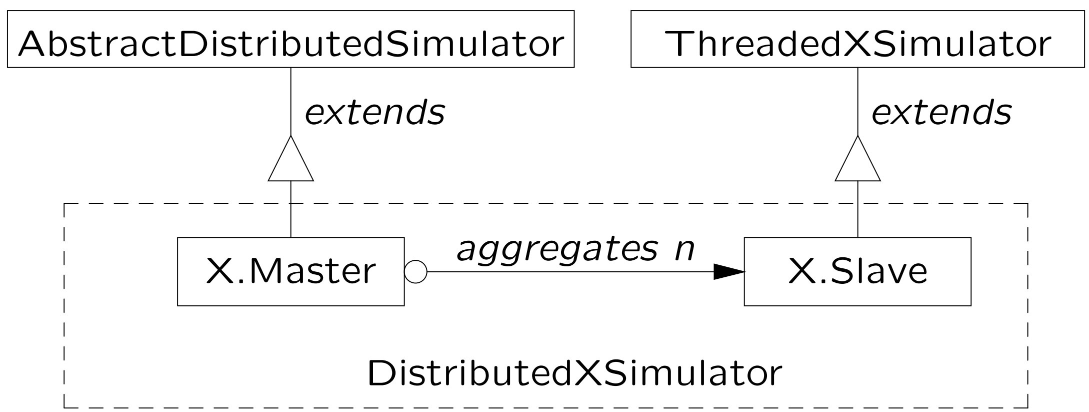

calls method
createProcess
simulator
instance
is bound to
system model
instance
creates
creates
calls methods
send(Message m)
schedule(Event e)
system process
instance
is bound to
entity model
instance
logical process
provided by Parsimony
user-defined

Simulators

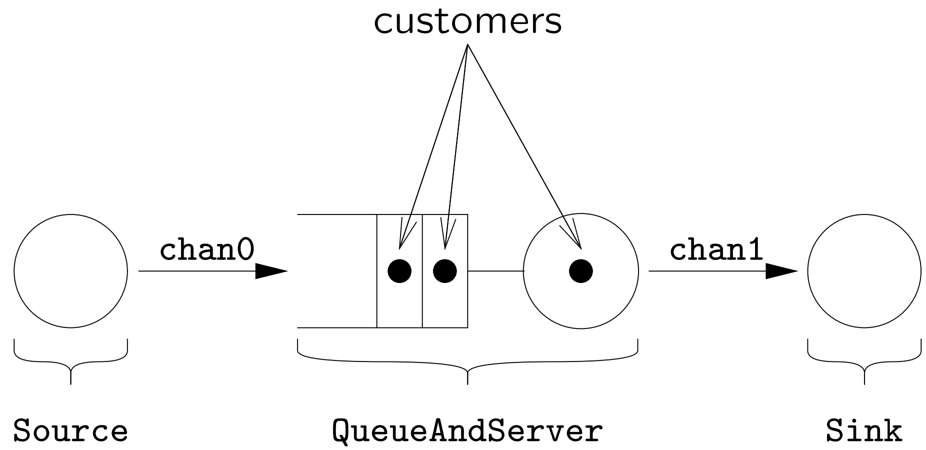
- `SequentialSimulator`
- `MultiListSimulator`
- `ThreadedMLSimulator`
- `ThreadedCMBSimulator`
- `ThreadedTWSimulator`
- `RealTimeSimulator`

Distributed Simulators

- `DistributedMLSimulator`
- `DistributedCMBSimulator`
- `DistributedTWSimulator`
- `DistributedRTSimulator`


AbstractDistributedSimulator
ThreadedXSimulator
extends
extends
X.Master
aggregates n
X.Slave
DistributedXSimulator

An Example—A Single-Server Queueing Network



Source Model

```
class Source extends AbstractModel
{
   RandomVariable interDepartureTime;

   public Source (long mean)
   {  super(0, 1);
      interDepartureTime = new ExponentialRV(mean);
   }

   public void initialize (long time)
      { schedule(new Departure(time)); }

   class Departure extends AbstractEvent
   {
      Departure(long time) { super(time); }

      public void run ()
      {  send(new VoidMessage(getTime()));
         schedule(new Departure(Math.round(getTime() +
            interDepartureTime.nextDouble())));
      }
   }
}
```

Sink Model

```
class Sink extends AbstractModel
{
   Sink ()
   {  super(1, 0);
      setMessageHandler(new ArrivalHandler());
   }

   class ArrivalHandler
      implements MessageHandler
   {
      public void run(Message message) {}
   }
}
```

Queue-and-Server Model

```
class QueueAndServer extends AbstractModel
{
   RandomVariable serviceTime;
   int numberInQueue = 0;
   boolean serverBusy = false;

   QueueAndServer (long mean)
   {  super(1, 1);
      serviceTime = new ExponentialRV(mean);
      setMessageHandler(new ArrivalHandler());
   }

   class ArrivalHandler implements MessageHandler
   {
      public void run (Message message)
      {  if (serverBusy) ++numberInQueue;
         else
         {  serverBusy = true;
            schedule(new Departure(Math.round(getTime() +
               serviceTime.nextDouble())));
         }
      }
   }
```

```
   class Departure extends AbstractEvent
   {
      Departure (long time) { super(time); }

      public void run ()
      {   send(new VoidMessage(getTime()));
         if (numberInQueue == 0)
            serverBusy = false;
         else
         {  --numberInQueue;
            schedule(new Departure(Math.round(getTime() +
               serviceTime.nextDouble())));
         }
      }
   }
}
```

System Model

```
class Queueing extends AbstractSimulation
{
   public void run ()
   {  Channel chan0 = createChannel();
      Channel chan1 = createChannel();
      createProcess(new Source(1000),
         new ChannelHead[] {}, new ChannelTail[] { chan0 });
      createProcess(new QueueAndServer(1000),
         new ChannelHead[] { chan0 }, new ChannelTail[] { chan1 });
      createProcess(new Sink(),
         new ChannelHead[] { chan1 }, new ChannelTail [] {});
      super.run();
   }
}
```

Summary and Conclusions

- Parsimony as vehicle for research in distributed discrete-event simulation

- project goals and status

- contributions of paper:
  - identification of requirements of discrete-event simulation with respect to the underlying implementation technology
  - show how Java language and JVM directly support these requirements