Modularization and Software Architectures

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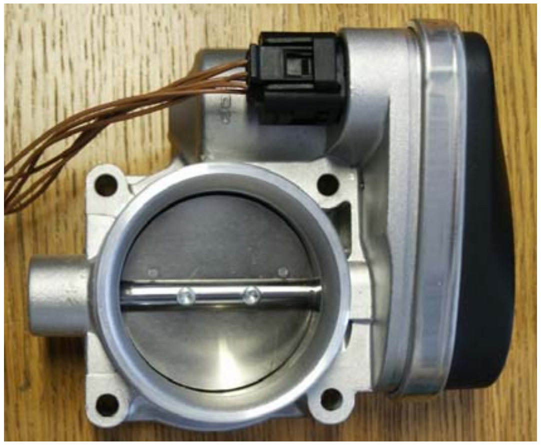
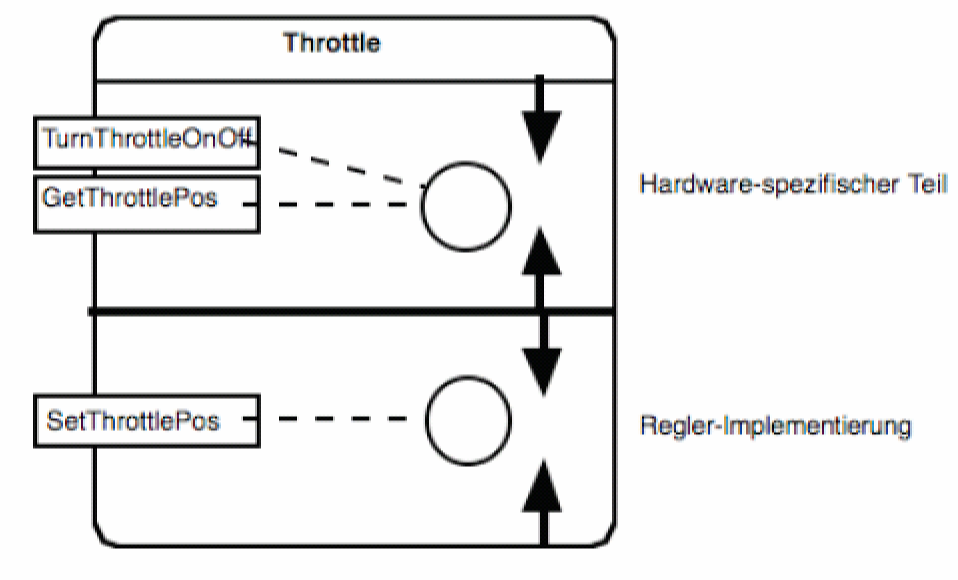
Improving Cohesion in the Butterfly Valve Example

```
interface Throttle {
  bool TurnThrottleOnOff(bool onOff);
  bool SetThrottlePosition(float angle);  // 0..90 Grad
  float GetThrottlePosition();
}
```



Low cohesion:



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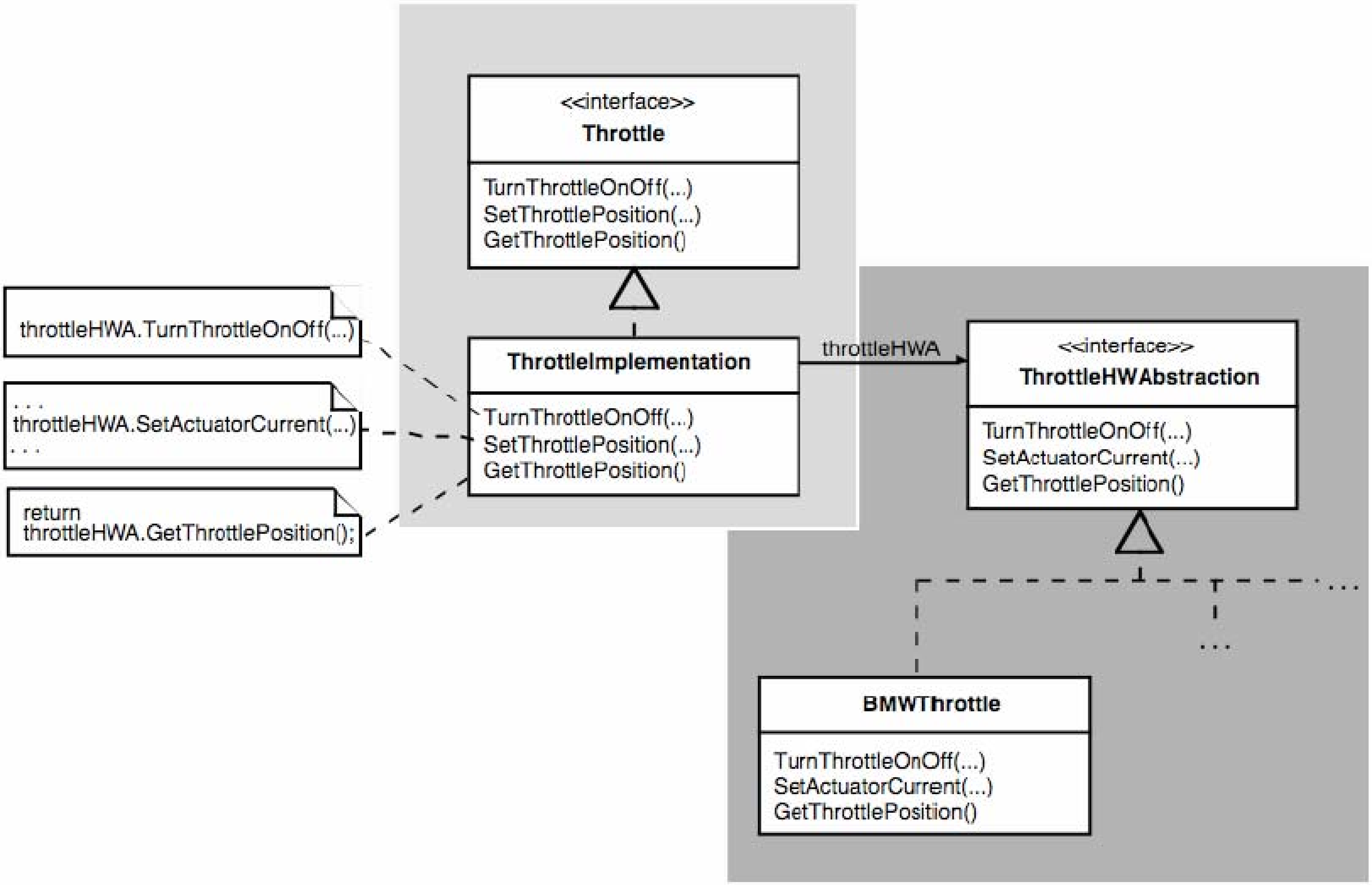
Split up the module Throttle while maintaining the interface



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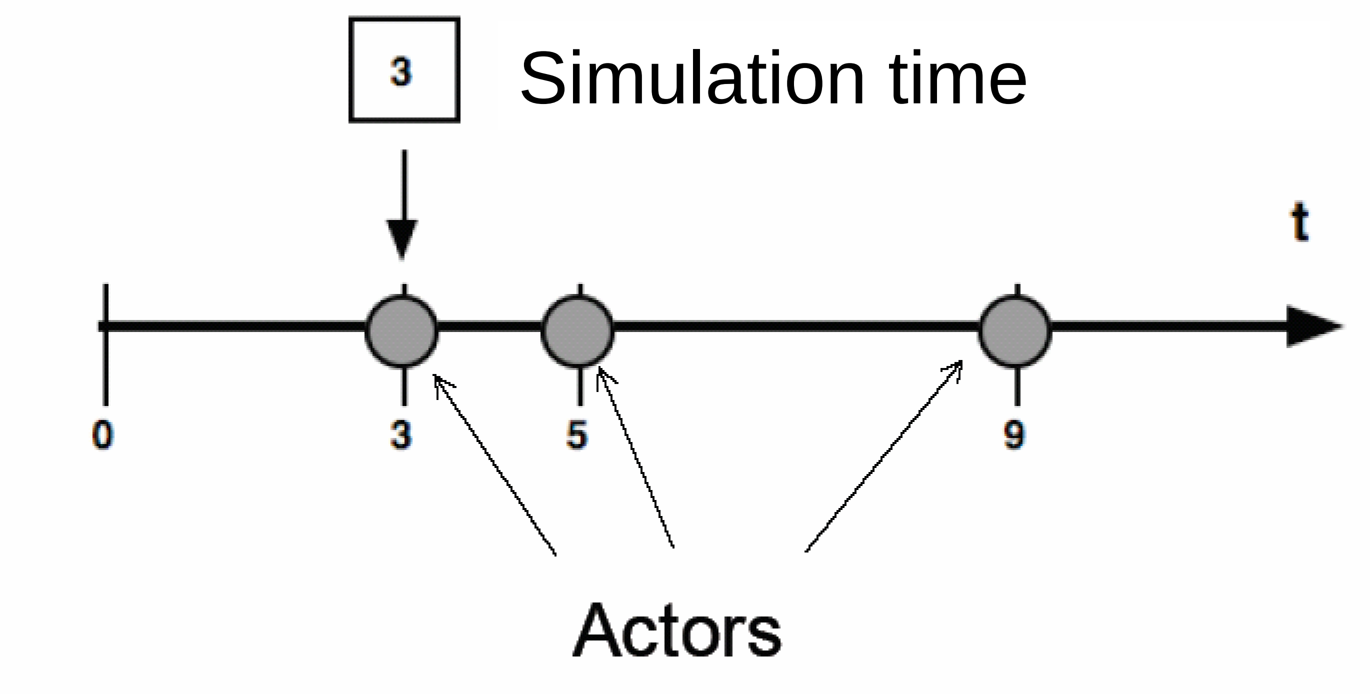
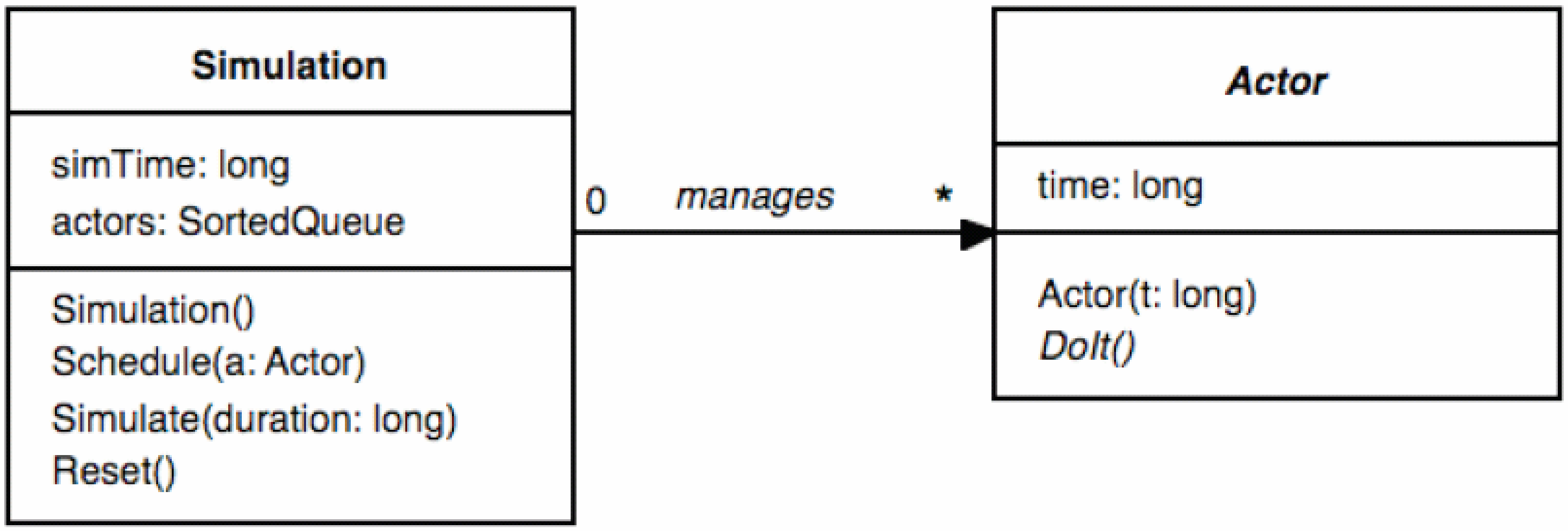
Example: Simulation of Discrete Events

Discrete Events on a Time Axis



Framework for discrete event simulation



Simulation

simTime: long
actors: SortedQueue

Simulation()
Schedule(a: Actor)
Simulate(duration: long)
Reset()

Actor

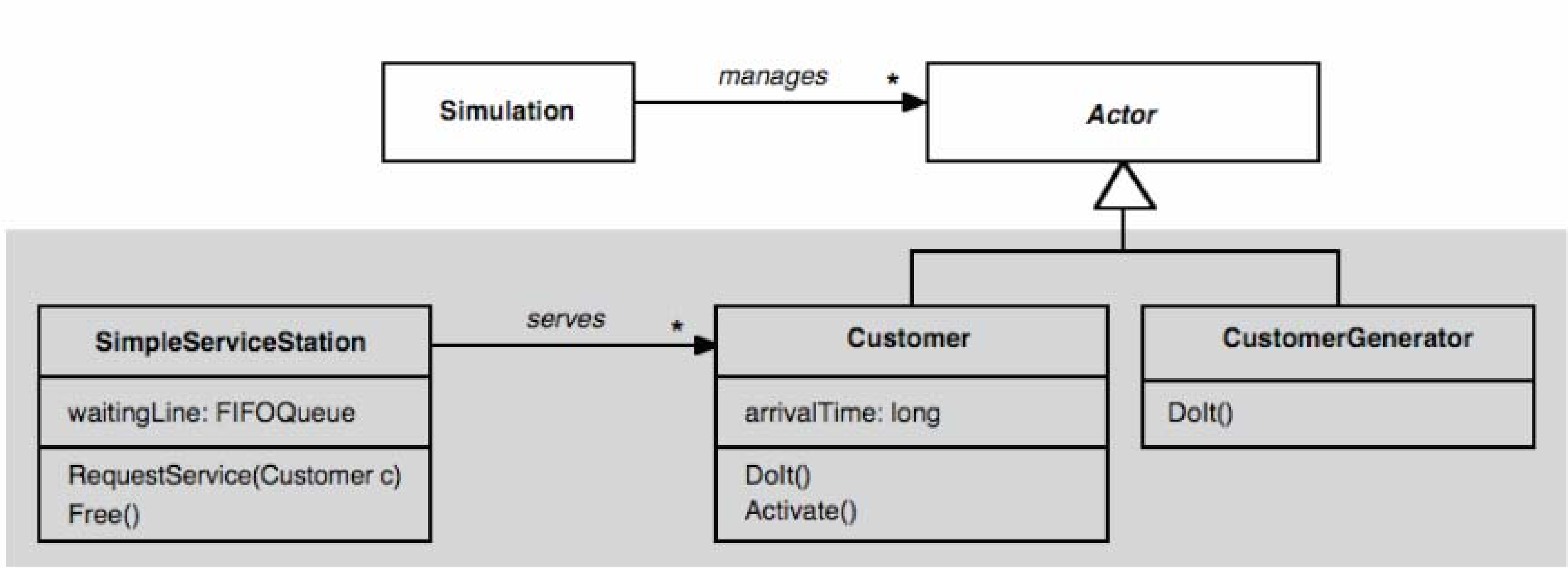
time: long

Actor(t: long)
DoIt()

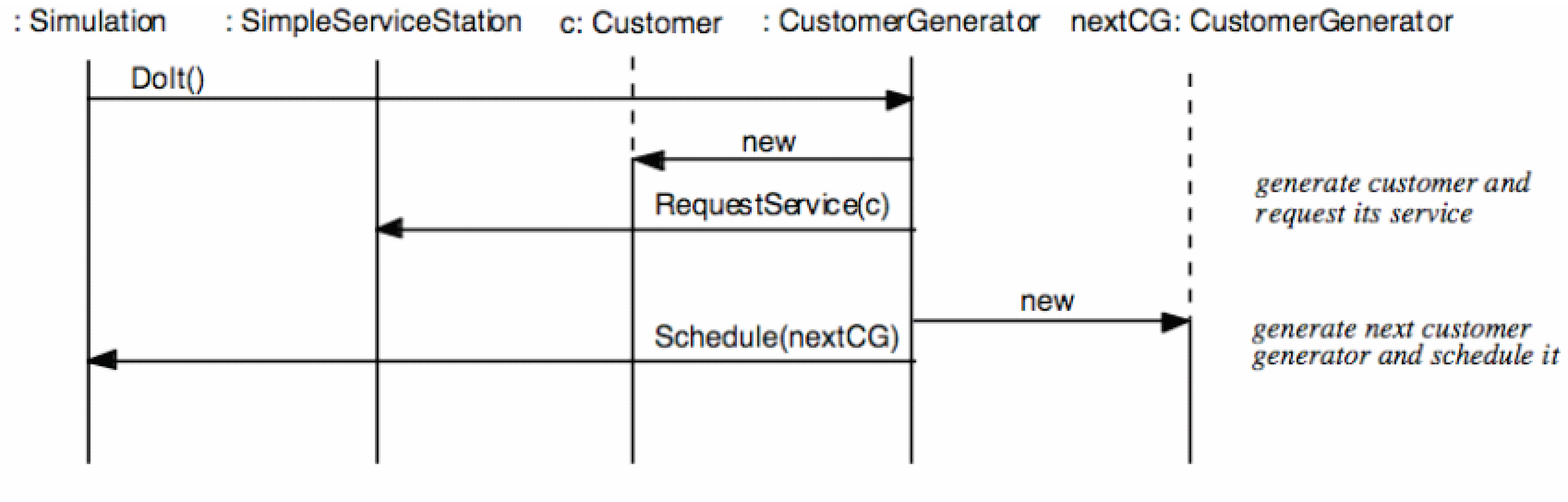
C# Implementation of Simulate()

```
public void Simulate(long duration) {
        long endOfSimulation= simTime + duration;
        do {
          if (actors.Count() != 0) {
                Actor actor= (Actor) actors.Dequeue();
                simTime = actor.time;
                actor.DoIt();
          } else      // no more actors enqueued
                break;      // exit loop
        } while (simTime <= endOfSimulation);
   }
```

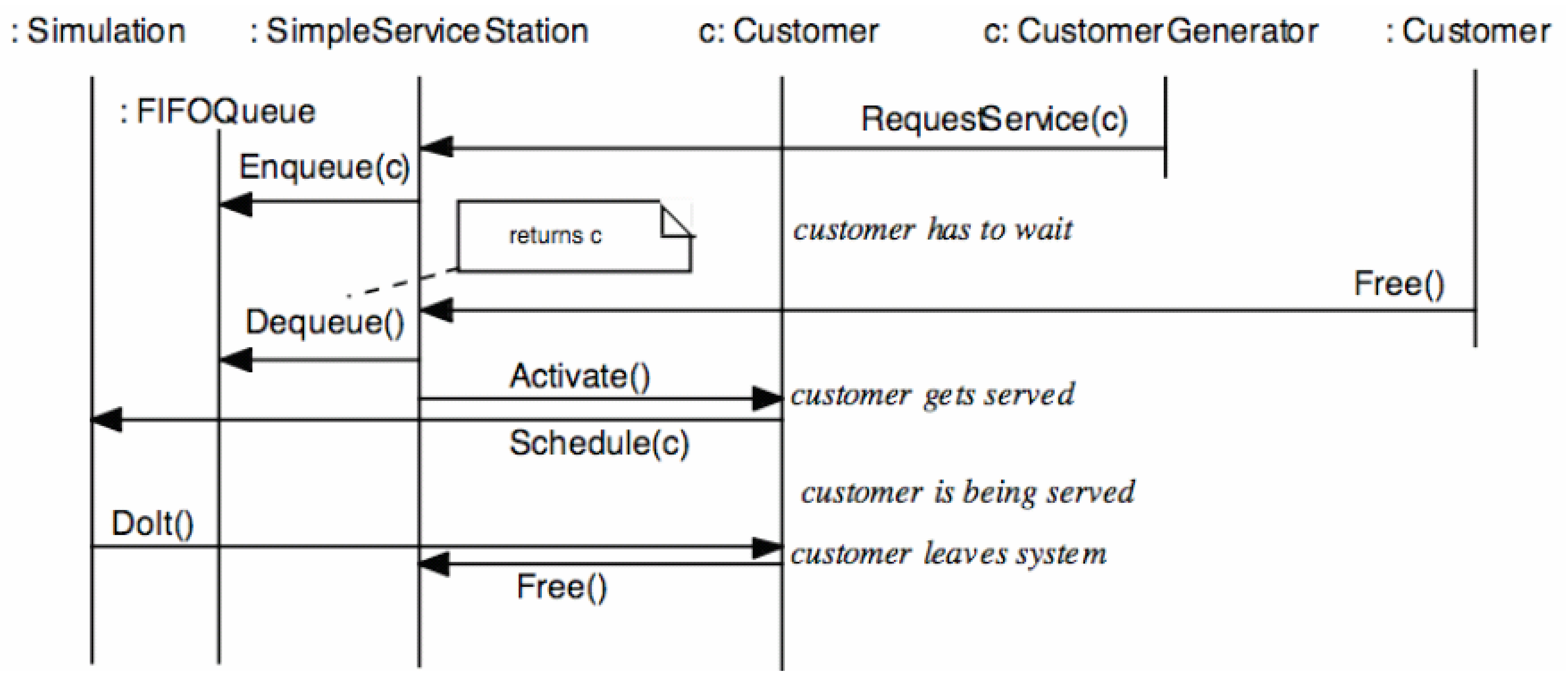
Classes for the simulation of a simple bank service counter



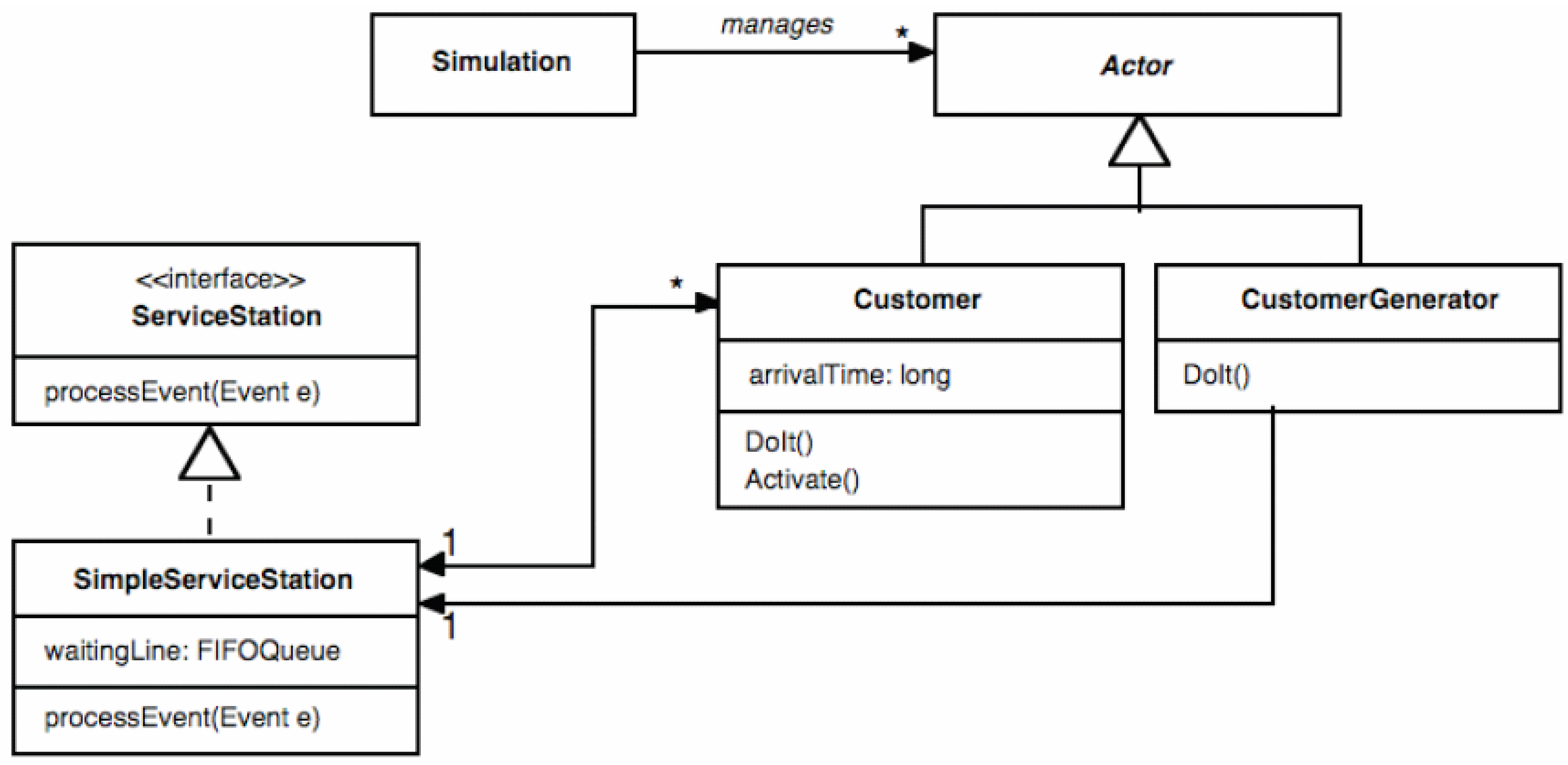
The DoIt() Method of Class CustomerGenerator


: Simulation
: SimpleServiceStation
c: Customer
: CustomerGenerator
nextCG: CustomerGenerator
DoIt()
new
RequestService(c)
new
Schedule(nextCG)
generate customer and request its service
generate next customer generator and schedule it

Lodging a customer in the queue



Decrease of the coupling between service station and the actors



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Description of Software Architectures

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Definition of Software Architecture

The assembly of all the components (modules) of a software system together with their interactions.

Architectural styles

- In the 90s, The Software Engineering Institute (SEI) of the Carnegie Mellon University in Pittsburgh, Pennsylvania, considerably contributed to the establishment of **architectural styles** for the description of software architectures.
- SEI originally suggested a dedicated notation for architecture description; since 2003, SEI has used also the UML for that.

Examples of well described software architectures

- *Project Oberon—The Design of an Operating System and Compiler* by Wirth and Reiser (Addison-Wesley 1992).

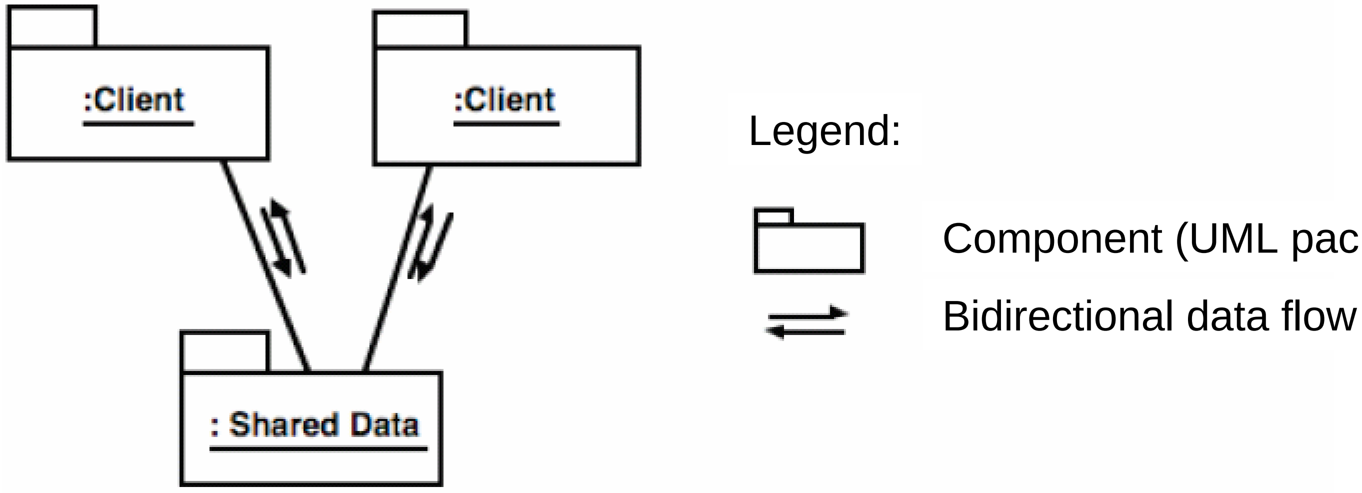
  The informal description is supplemented by schematic representations, screenshots, and source text.

- *Design Patterns* of Gamma et al. (Addison-Wesley 1995)

Overview of SEI architectural styles

Architectural style	**Characteristics**
Data-centered	Repository Architecture Blackboard Architecture
Data-flow	Batch/Sequential Architecture Pipes&Filters Architecture
Call & Return	Top-Down Architecture Network Architecture (Object oriented) Layered Architecture
Virtual Machine	Interpreter Architecture Rule-based Architecture
Independent Components	Event-driven Architecture

Data-centered (I)



Legend:

Component (UML package)

Bidirectional data flow

- In a Repository architecture the data is passive.
- A Blackboard architecture has quasi-active data, which informs the clients interested in changes. The Blackboard architecture style is similar to the Observer design pattern (Gamma et al., 1995).

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Data-centered (II)

Advantage:

- Clients are independent from each other. Thus, a client can be changed, without affecting the others. Also further clients can be added.

- This advantage pales if the architecture is changed in such a way that clients are coupled closely (thus deviating from the recommended architecture style), for example in order to improve the performance of the system.

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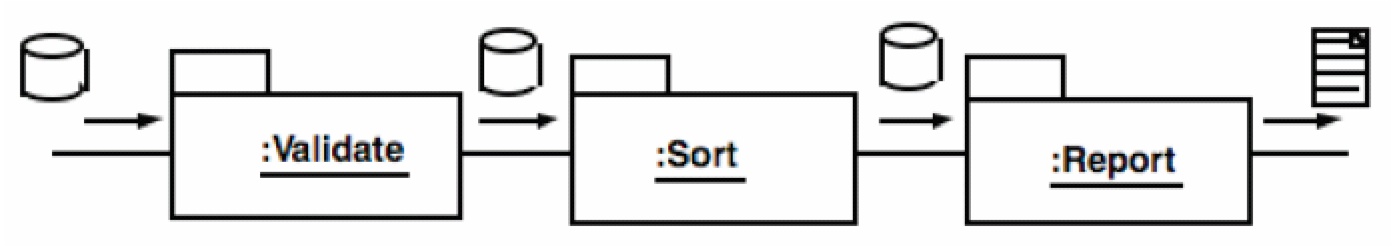
Data-centered (III)

Issues that must be addressed:

- Data consistency - synchronization of read/write operations
- Data security, access control
- Single point of failure

Data-flow style: Batch/Sequential



- The style describes a succession of transformations of input data.
- Data flow-oriented architecture parts are particularly characterized by reusability and modifiability.
- In the Batch/Sequential form, each transformation procedure must be terminated before the next one begins.

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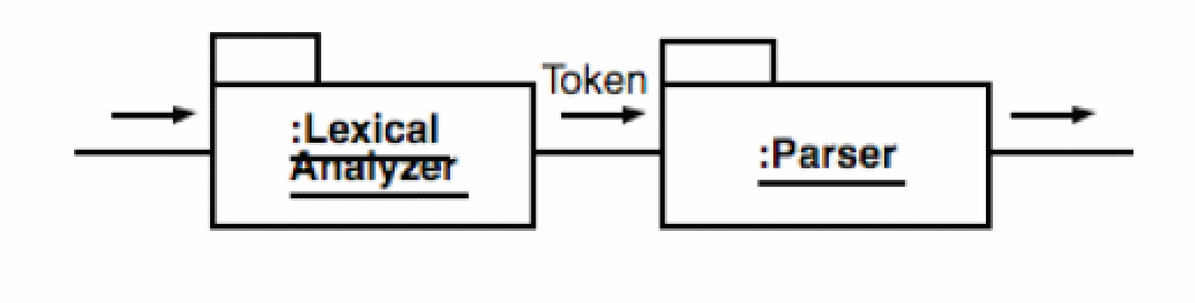
Data-flow style: Pipes&Filters



- In the Pipes&Filters form, data is incrementally (not sequentially in blocks) transformed. That is, the data is divided into smaller units and these units are processed by the processes.
- Pipes are stateless and transport the data from filter to filter in such a way that each filter autonomously determines when it needs the next element (input) of the data stream from the preceding filter.
- The difference between Pipes&Filters and Batch/Sequential is not evident in a UML representation.

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Data-flow style: Advantages and Disadvantages

- The main advantage of data-flow is the low complexity of interactions between components. The processing modules are black boxes.
- The data-flow-oriented architecture style is unsuitable for modeling interactive applications.
- A further disadvantage is the frequently insufficient performance and efficiency. If filters need the entire input stream as context, appropriate buffers must be used. That affects the memory efficiency negatively.
- The data-flow style is well suited as basis for visual-interactive composition. It is used for example in the tool Simulink (from MathWorks).