OOCP = OOP + C

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Abstract

This position paper argues that Object-Oriented Programming (OOP) is currently the best tool to prototype Object-Oriented Concurrent Programming (OOCP). Three aspects are considered: implementation, description ability, and programming environment. The Actalk system (which stands for actors in Smalltalk) is used along the discussion as an example supporting our position statement.

The tutorial on Concurrent Object-Oriented Programming in this conference has also been based on such an approach.

Keywords

object, concurrency, actor, implementation, prototyping, classification, modularity, extensibility, inheritance, genericity, visualization, programming environment, Smalltalk-80, ConcurrentSmalltalk, Actalk.

1 Introduction

The position we defend in this paper is:

"Object-Oriented Programming (OOP) is currently the best paradigm to describe Object-Oriented Concurrent Programming (OOCP) [OOCP 87]"

We summarized this statement in the title "equation":

"OOCP = OOP + Concurrency"

If we take a reflective approach, OOCP itself would be the best candidate to describe OOCP. Reflection is a very promising research direction. However it is still in infancy in the field of OOCP, the most advanced proposal being the reflective description of the ABCL/1 language by Watanabe and Yonezawa [Watanabe and Yonezawa 89]. Thus we chose to restrict the complete OOCP model to some subset: (sequential) OOP. Because OOP is still much more developed than OOCP, we gain efficient and sophisticated environments to quickly design, classify and visualize OOCP.

A system, named Actalk [Briot 89], will be used along this position paper to examplify and validate our po-

sition. Actalk uses descriptive and visual ability of the Smalltalk-80[1] environment to provide a testbed for designing and classifying actor-based languages. Actor-based languages [OOCP 87, pages 37–53] are one of the most active and open family of OOCP languages. For this reason we did not want to set a new OOCP language. Our goal is to provide an open testbed to model various OOCP languages and to experiment them within a single and unified environment. Besides its different concern, Actalk is also much related to the ConcurrentSmalltalk language [OOCP 87, pages 129–158], which extends Smalltalk-80 towards concurrency.

2 Advantages of OOP to Describe OOCP

The merits of choosing OOP as a basis to describe OOCP will now be discussed along three successive points:

- At first we will discuss the implementation support. We will review why OOP gives for free the best support for OOCP, regarding minimality and modularity.
- The second point is about the descriptive ability of OOP. We will show that classes, inheritance and genericity are very useful tools to describe OOCP.
- We will complete our survey by discussing the gain of reusing the integrated and modular programming environment of Smalltalk-80. This underlying environment will be used to prototype environments suitable for OOCP.

[1]Smalltalk-80 is a trademark of ParcPlace Systems.

3 Implementation Ease

3.1 Minimality for Pedagogy

OOCP languages introduce the notion of active and concurrent objects. Smalltalk-80 provides all entities needed to build them: objects, classes and messages, and to express concurrency: processes and semaphores. Thus implementation is both high level and minimal. This allows focusing on the semantics of OOCP and the differences with standard OOP, rather than dealing with low level concerns.

3.2 Combination for Reuse

Actalk models OOCP by defining a sub-world of active objects embedded into the world of standard objects. This leads to a modular implementation and a good combination between passive and active objects. This results in the maximal reuse of the underlying system.

3.3 Modularity for a Layered Architecture

The kernel of the Actalk system which describes the minimal semantics of active objects is defined by two simple classes. The first class, named `Actor`, defines the semantics of active objects (actors) and their asynchronous communication, and the

class `ActorBehavior` defines the semantics of their behaviors. The class `Actor` simply defines an actor through its two components, the mailbox or queue which will contain the incoming messages, and the behavior which will process them. The class `ActorBehavior` expresses the default semantics of the activity of behaviors, i.e., keep dequeueing and performing messages from the mailbox. Both classes may be extended by using inheritance in order to simulate various OOCP models.

4 Descriptive Abilities

4.1 Classes for Abstraction

Classes of behaviors of actors are implemented by standard abstractions available in OOP, i.e., classes. Consequently, the language designer and the programmer may use the standard Smalltalk-80 classification system and environment (browser) to define new OOCP models and programs.

4.2 Inheritance for Classification

In order to simulate some of the most representative OOCP computation models and programming languages based on the actor concept, we use the main classification tool of OOP, i.e., inheritance. Various models will be described as progressive extensions of the primitive kernel.

A first extension simulates the Actor computation model of Agha and Hewitt [OOCP 87, pages 37–53] as a subclass of class `ActorBehavior`, named `AghaActorBehavior`. Only two methods need to be defined in class `AghaActorBehavior` to implement the concept of *behavior replacement*, i.e., how to process next incoming message.

The second example simulates the Abcl/1 programming language of Yonezawa [OOCP 87, pages 55–89] as a subclass of class `Actor`. This extension easily implements three distinct types of communication protocols between actors: asynchronous, synchronous and eager types of message passing.

These simulations show the merits of modularity for our kernel. Because the kernel and its extensions are related by inheritance, one could easily compare them. Inheritance helps not only to classify various actor models, but also to clearly relate and to reuse their various implementations.

4.3 Genericity for Modular Control

Another extension of the Actalk kernel introduces a generic control of actor events (i.e., receiving a message, computing it...) into Actalk. This is implemented by defining generic event methods instantiated for various applications. We currently use this facility to design actor event driven representations (views) of actors. This may also be used to control pseudo-parallel execution of actors by associating scheduling to actor events.

5 Environment Support

5.1 Reuse of the Standard Programming Environment

A good programming environment is important for prototyping and experimenting with sequential languages. It becomes a near necessity when experimenting with concurrent languages. However it is usually lacking because the task, specially for debugging, is not trivial. Building a complete programming environment is a long and big task. Smalltalk-80 is the most achieved and flexible OOP system with a fully integrated programming environment. Because of the integration of our actors into the Smalltalk-80 model and environment, the designer of actor languages and the programmer could automatically reuse the standard Smalltalk-80 programming environment.

5.2 Extension Towards a Specific Environment

However, the standard Smalltalk-80 programming environment cannot take into account some specificities of OOCP. For example, the debugger does not show much relevant information when asynchronous message passing is used. Also the Smalltalk-80 MVC (Model View Controller) paradigm for interface design makes strong hypotheses about the sequentiality of the language. Therefore reframing a view on some active object updating itself may cause some chaotic redisplay.

Consequently it is necessary to customize the standard programming environment. By using inheritance to extend it, we may quickly design such specific environments. We extended the standard Smalltalk-80 programming environment in order to visualize, interactively monitor, and debug the activity of concurrent objects. We added some tools such a preemptive generic scheduler, a scheduling monitor, and an automatic interface generator [Briot and Lescaudron 90].

6 Conclusion

In this paper we advocated the use of current OOP support, precisely the Smalltalk-80 system, to design and experiment with OOCP programming. We believe this is a promising approach both for designers wishing to prototype OOCP systems and users wishing to study and experiment programming with them.

As an example of application, Actalk is being used by another research team in order to describe various Distributed AI systems, by extending the concept of actor into the concept of agent. One such realization is the Mages multi-agent system [Bouron et al. 90].

The views expressed in this paper were first discussed at the Workshop on Object-Based Concurrent Programming, held during the ECOOP'89 Conference.

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