The Future of Autonomous Decentralized Systems

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Introduction

Over the past fifty years the size of computer applications, as gauged by any reasonable measure, has increased exponentially. In contrast, our cognitive capabilities for understanding have not changed. This discrepancy has forced us to look for more abstract representations of systems to reduce the number of elements we have to consider simultaneously in order to understand the system behavior. In this contribution we argue that the next unit of abstraction, beyond the component concept, will be a subsystem that performs a specified service autonomously despite the occurrence of disturbances that were not foreseen in the original design.

Process of Abstracting

With the increase in the size of a computer applications, a sequence of more abstract concepts to express the computational intentions of a user have been introduced over the years. At the beginning of the computer era the service of a computer was specified by presenting a list of machine instructions that must be executed by the physical machine. To be able to abstract from the detailed hardware features of a particular machine, assemblers were introduced in the next phase to specify the instruction for a more general virtual machine. In the following years assemblers were replaced by compilers that translate a higher level representation of an algorithm into a form that can be executed by the computer hardware. Objects that encapsulate a computational method and the associated state into a single item were the next units of abstractions. At present we are introducing the notion of a component as a still higher unit of abstraction in the design of large computer systems. Although there is an agreement that a component forms a building block in the design of a large system, there is, at present, no agreement in the community as to what precise properties a component must have. Whereas the concept of a system component, that is an encapsulated hardware-software unit that delivers a specified service across a component interface is reasonably clear, the exact meaning associated with the term software component is still nebulous. For example, the question whether a software component contains state is a topic of intense discussion.

Beyond Components

Let us speculate what will be the unit of abstraction beyond the component age. We conjecture that the next unit of abstraction will be a nearly independent subsystem that provides its services across a well specified interface. The subsystem can decide autonomously how the specified service is realized under the given circumstances. In a large system there are many possibilities for substantial disturbances that cannot be all anticipated by the designers. To cope with these disturbances, the subsystems must have the capability to adapt to a changing environment autonomously in order to provide the best response to a specified service request. The subsystem is free to select the most appropriate approach for the given situation.

An Example

Consider, for example a braking subsystem in a car. The braking subsystem receives the command to decelerate the car by a certain amount. There are a number of different means to reduce the speed of a car: be reducing the power of the engine, by switching a regenerative alternator into the power-train, by applying conventional brakes to the wheels, by using a secondary emergency brake, or under extreme circumstances when the roads are covered by snow, by steering the wheels into a “snow-plow” mode. Depending on the current conditions, the braking system can decide autonomously which mechanism to select. In case one of the subsystems within the braking system has failed, the braking system can select an alternative mechanism to achieve its goal. The user of the braking system does not specify how to brake, but the intended effect of the braking action.

Conclusion

To manage the enhanced computational capabilities of the networked computer systems of the future, we need to present the system functions at a level of abstraction that matches the limited cognitive capabilities of the human mind. We conjecture that an autonomous subsystems that is free to decide how to achieve the specified goal will be such a unit of abstraction in the future. Therefore we view the future of autonomous decentralized systems with great expectations.