DOCTORAL THESIS

Autonomy oriented computing (AOC) for web intelligence (WI): a distributed resource optimization perspective

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Autonomy Oriented Computing (AOC) for Web Intelligence (WI): A Distributed Resource Optimization Perspective

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Abstract

Since its inception, the World Wide Web (the Web in short) has been evolving in an astronomical speed. It has greatly impacted and will continue to impact human daily life. Liu, Zhong, and Yao envisioned that the next generation of the Web will be the *Wisdom Web* from which Web users can gain practical wisdom of living, working, learning, and playing. In order to systematically addressing Web related research issues, they proposed *Web Intelligence* (WI) as a new research area. Liu argued that to achieve the Wisdom Web, WI has to overcome three great challenges:

1. Discovering the best means and ends;
2. Mobilizing distributed resources;
3. Enriching social interaction.

This thesis investigates two main issues involved in mobilizing distributed resources, namely, *distributed resource optimization* and *Web oriented computing paradigm*. The former concerns how to manage (to a certain extent) and optimize distributed Web resources. The latter focuses on developing computing paradigm suitable to those optimization problems arisen from the former issue.

In the thesis we view WI from a distributed resource optimization perspective. Specifically, we propose a generalized distributed resource optimization problem for WI, which concerns how to distribute service requests to different resource nodes such that their service request load is approximately balanced. Accordingly, they are utilized in an approximately optimal way. We then provide an Autonomy Oriented Computing (AOC) based approach for the proposed problem. AOC is a multi-entity

based methodology for addressing complex systems modeling and computationally hard problem solving. Its essence lies in the idea of self-organization of autonomous entities through interactions. Due to this reason, it is quite suitable to those large-scale, highly distributed problems. In the provided approach, autonomous agents are employed to carry service requests submitted to a resource environment in order to find appropriate resource nodes for them. They indirectly interact with each other via the resource environment (e.g., the joining or leaving of an agent at a resource node influences the decision making of other agents on whether or not joining or leaving this resource node). Through this interaction mechanism, agents may self-organize themselves and distribute service requests to resource nodes to achieve load balancing and resource optimization.

Usually, Web-based resource environments can be classified into two types, namely, homogeneous environments and heterogeneous environments. By fully considering the distinct features of these two types of resource environment, we refine the above proposed AOC-based resource optimization mechanism into two specific ones. For the mechanism suitable to homogeneous environments, we propose mathematical models to macroscopically characterize the process of resource optimization. Through numerical simulations of the models and experiments on a computing platform, called *SSADRO*, we validate the proposed mechanism. For the one suitable to heterogeneous environments, through experimentation also on the SSADRO computing platform we validate its properties, such as, effectiveness and robustness.

In general, this thesis tries to integrate Web Intelligence (WI) and Autonomy Oriented Computing (AOC): (1) It introduces Autonomy Oriented Computing (AOC) as a general methodology to Web Intelligence (WI) for addressing the issue of distributed Web resource optimization; (2) Through the distributed Web resource optimization problem, it re-validates the effectiveness of AOC in solving real-world, large-scale, highly distributed problems.

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