情報処理学会
グループウェアとネットワークサービス研究会
2005年11月10日, 11日

理論グリッドとグリッド理論家

(ポジションペーパー)

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概要： 集合知として理論グリッドを構築し、それに基づいて自動定理発見および自動問題提示を行うグリッド理論家を実現するという新しい研究方向を提案する。

Theory Grid and Grid Theorists

(Position Paper)

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Abstract. This position paper proposes a new research direction: to build Theory Grid as the wisdom of crowds, and then to implement Grid Theorists working based on theory grids with the ability to find new theorems and propose new questions automatically.

"In mathematics the art of proposing a question must be held of higher value than solving it."
– G. F. L. P. Cantor, 1867.

1. Introduction

Wos in 1988 proposed 33 basic research problems in automated reasoning [21, 22]. The 31st one is the problem of automated theorem finding (**ATF** for short): "What properties can be identified to permit an automated reasoning program to find new and interesting theorems, as opposed to proving conjectured theorems?" The **ATF** problem is still completely open until now. The most important and difficult requirement of the problem is that, in contrast to proving conjectured theorems supplied by the user, it asks properties and/or criteria such that an automated reasoning program can use them to find some theorems in a field that must be evaluated by theorists of the field as new and interesting theorems. The significance of solving the problem is obvious because an automated reasoning program satisfying the requirement can provide great assistance for scientists in various fields. Note that the **ATF** problem requires general properties and/or criteria that an automated reasoning program should be obedient to, but not some concrete theorems in a special field. Therefore, any of those automated reasoning programs [15, 23, 17, 8] to discover or prove some concrete theorems in a special field by heuristic search has nothing to do with the **ATF** problem. The **ATF** problem also requires that an automated reasoning program can use the properties and/or criteria to find "new and interesting" theorems, but not those known or trivial ones. Finally, from the description of the **ATF** problem, we can see that it explicitly requires properties and/or criteria of an individual automated reasoning program.

Any scientific discovery was not completely based on only one scientist's wisdom and experiences but must have achieved as a result of endeavors by many scientists. This observation should be really true in the world of today. On the other hand, the concept of grid in Grid Computing discipline is defined as the controlled and coordinated resource sharing and problem solving in dynamic, multi-institutional virtual organizations [9-13]. The Grid Computing technologies and/or activities involve networking services, connections, and communication of an unlimited number of resources within a virtual organization, and therefore, the Grid Computing has been refereed as the world's largest computer [9-13]. This position paper considers a revised edition of the **ATF** problem: "What properties can be identified to permit a crowd of automated reasoning programs to find new and interesting theorems, as opposed to proving conjectured theorems?" It proposes a new research direction: to build Theory Grid as the wisdom of crowds, and then to implement Grid Theorists working based on Theory Grid with the ability to find new theorems and to propose new questions automatically. A conjecture of the present author to motivate this research direction is that maybe a crowd of automated reasoning programs can more easily find new and interesting theorems than an individual automated reasoning program.

2. Theory Grid and Grid Theorists

A ***Theory Grid*** is a formal theory infrastructure that coordinates various formal theories (represented by various

formal logic systems) in a distributed way using standard, open, general-purpose protocols and interfaces to meet demands of its application programs for theorem discovery and/or question proposition.

The concept of Theory Grid differs from the concepts of Computational Grid and Data Grid in that the Theory Grid concerns coordinated formal theory sharing for theorem discovering and/or question proposing. From the viewpoint of architecture, a theory grid should be built on the top of a computation and/or data grid computing environment. Therefore, if an intrinsic function of a grid computing environment is to provide its users with standard, open, general-purpose protocols and interfaces for computational power and data sharing, then a similar intrinsic function of a theory grid is to provide its users with standard, open, general-purpose protocols and interfaces for formal theory sharing always.

For the fundamental logic system to represent formal theories, the present author's preference is relevant logics [1, 2], in particular, strong relevant logics, because they are really suitable to discovery [4-7]. Note that a theory grid should be independent of formal theories and their underlying logic systems.

A ***Grid Theorist*** is a crowd of (an unlimited number of) automated reasoning programs working together on a Theory Grid in order to discover new and interesting theorems and/or propose new and interesting questions in a special field. A successful grid theorist should have the ability to discover new and interesting theorems and/or propose new and interesting questions by a systematic way that can be learnt by other grid theorists. Can we implement such a successful grid theorist?

3. Related Works

The works to find a systematic methodology of scientific discovery started at least from Popper's work [16]. Historically, scientific discovery is the most important subject studied in history of science and philosophy of science, and just recently, it became the research subject of some cognitive scientists and computer scientists who believe that the process of a scientific discovery can be described and modeled in a normal way and therefore it can be simulated by computer programs automatically [14, 18, 19]. Wos's **ATF** problem can be regarded as an attempt to find a systematic methodology in automated reasoning area. From the 1970s, there have been some works on mathematical theorem discovery and proof [15, 23, 17, 8]. But, as we have mentioned in Section 1, these works have nothing to do with the **ATF** problem. The knowledge grid proposed by Cannataro and Talia is a reference software architecture for parallel and distributed data mining on grids [3]. Finally, Surowiecki has investigated the wisdom of crowds [20]. The position of this paper is to show a new research direction to find a systematic methodology for theorem discovery and/or question proposition using the wisdom of crowds coordinately shared by grid computing technologies.

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