On Nonredundant Cost-Constrained Team Formation

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ABSTRACT

Due to the wide application of the task assignment on the internet, team formation problem has become an important research issue. A recently proposed problem ClusterHire aims to find a team of experts to accomplish multiple projects which can harvest a maximum profit under a limited budget. However, there exist redundancies in the team yielded by existing algorithms. This paper first studies the properties of the problem, and give two pruning strategies based on them. Secondly, a redundancy-eliminating strategy and a team-augmenting strategy are proposed. In addition, a new algorithm for generating a profit-maximizing team is also proposed. It is based on the redundancy-eliminating and team-augmenting strategies. The experimental evaluations show that our proposed strategies and algorithms are effective.

KEYWORDS
Cluster Hire, Expert-Skill-Project Tripartite Graph, Set Cover, Task Assignment, Team Formation

1. INTRODUCTION

The team formation and the task assignment on the internet are related to each other. They can be applied to many areas, e.g. online labor market, social activity organization. Recently, a variant of team formation problem, called ClusterHire (Golshan & Terzi, 2014), proposed to form a cost-constrained profit-maximizing team. Given a set of experts, a set of skills and a set of projects, each expert possessed some skills, and each project required some skills. Each expert was associated with a compensation demand, and each project was associated with an expected profit. The goal was to find a team of experts whose cost did not exceed the given budget, and maximize the total profit of projects. In the real world, the online labor market like www.guru.com can recommend teams for their employer users, and recommend projects for their employee users using the above formulation.

In article (Golshan & Terzi, 2014), the authors first proposed the ClusterHire problem. It was proved NP-hard, and three heuristic algorithms, respectively called ExpertGreedy, ProjectGreedy and CliqueGreedy, were introduced. However, we discover that they have some following limitations. (1) ExperGreedy picks an expert maximizing the cost performance, i.e. the ratio of the profit increment before and after picking this expert to the cost of this expert, for the current team every time. Without DOI: 10.4018/IJDWM.2017070102

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loss of generality, let $T$ is the current team and $e$ is the picked expert with the maximum cost performance. There exists a scenario that the skill set of some experts in $T$ is properly included in that of $e$. Obviously, the expert in $T$ is redundant, and should be removed. ProjectGreedy takes a different greedy strategy operating on projects from ExpertGreedy. Similarly assume that $T$ is the current team, and $P$ is the set of projects not covered by $T$. It computes an expert set $X_p$ for each $p \in P$ using greedy set cover algorithm, and then selects the project $p'$ maximizing the cost performance, i.e. the ratio of the profit increment to the cost of $X_p$, from $P$. Obviously, there also exists the same problem with ExpertGreedy, i.e. the skill set of experts in $T$ is properly included in that of $X_p$. CliqueGreedy is an extension of ProjectGreedy. It first groups the projects with similar or near-identical skills, and then generate a team via ProjectGreedy. Therefore, redundancies may also occur to CliqueGreedy. Overall, there always exist redundancies in ExpertGreedy, ProjectGreedy and CliqueGreedy. The redundant experts should be removed, because the skill set of picked experts covers that of the existing experts in the current team. That is to say, they are replaced with the experts with more skills. Below, we explain the feasibility and desirability of eliminating redundancies from the theoretical and pragmatic point of view. To theoretically solve the ClusterHire problem, some other experts may be added to the team after eliminating redundancies, and thereby we can get a better team to make a larger profit. From the pragmatic point of view, eliminating redundancies is also good for employers and freelancers. On side of employers, many online labor markets such as oDest (www.odesk.com), Freelancer (www.freelancer.com) and Guru (www.guru.com) now offer team-hiring services to their enterprise customers. Some companies could outsource the projects in his hand, which they would not devote themselves to, to some teams with fixed payment if they accept this service. Note in particular that these projects are relatively small, and not their core business. Thereby, they hire some teams to complete these projects with fixed payment. For the hired team consisting of freelancers with complementary skillsets, everyone gets payment according to his/her amount of work. In consideration that the project is relatively small, it is not necessary to hire the experts with redundant skillset. In addition, they also do not wish to hire a redundant employee to join them, because the payment obtained by them will decrease accordingly. On side of freelancers, some freelancers with complementary skillsets in online labor markets wish to unite up to pursue a larger profit. They cooperate remotely on some projects, and respectively gain payment according to their respective amounts of work. Obviously, redundant freelancers will decrease the payment of other freelancers more or less. Under these scenarios, the redundant experts are invaluable to the team, and therefore eliminating them has no influence on the projects. (II) Article (Golshan & Terzi, 2014) only provided three heuristic algorithms, but did not study the properties of ClusterHire. That is to say, the authors did not consider whether there were effective pruning strategies based on the properties of ClusterHire.

Motivated by these limitations, we want to overcome them. For ease of presentation, the ClusterHire problem is modeled via a tripartite graph. We first provide a redundancy-eliminating approach to improving the results of ExpertGreedy, ProjectGreedy and CliqueGreedy. This method is inspired by the greedy algorithm for the SetCover problem. Then, we further augment the resultant team via a team-augmenting strategy, because some other expert may be added to the team after eliminating redundancies. For showing the generality of the redundancy-eliminating and team-augmenting strategies, we devise a new heuristic strategy to yield a candidate team. Then, we use the above two strategies to improve the candidate team. In addition, we also investigate the properties of the ClusterHire problem, give two effective pruning strategies based on them. These two pruning strategies operates on the search tree consisting of the subsets of the expert set $X$. The search tree can be constructed according to the method in article (Liu & Wong, 2008). A trivial pruning strategy is that the total cost of some node in the search tree exceeds the specified budget, then the node and its descendants can be pruned. Our proposed pruning strategies are respectively motivated by the fact that (1) the total profit made by some node is less than the baseline profit which is updated dynamically,
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