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Auction-based crowdsourcing supporting skill management

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ABSTRACT

Crowdsourcing is a promising approach for enterprises to maintain a flexible workforce that is able to solve parts of business processes formerly processed in-house. Companies perceive crowdsourcing as a concept that allows receiving solutions quickly and at little cost. Similar to cloud computing where computing power is provided on demand, the crowd promises a flexible on-demand workforce. However, businesses realize that these benefits entail a lack of quality control. The main difference compared to traditional approaches in business process execution is that tasks or activities cannot be directly assigned to employees but are posted to the crowdsourcing platform. Its members can choose deliberately which tasks to book and work on. In fact, crowdsourcing is heavily affected by the loose-coupling of workers to crowdsourcers and the dynamics of the environment. Hence, it remains a major challenge to guarantee high-quality processing of tasks within the prescribed time limit. A further obstacle for adoption of crowdsourcing in enterprises is the fact that it is hard to specify a fair monetary reward in advance. The concepts introduced in this work allow to smoothly integrate new workers, to keep them motivated, and to help them develop and improve skills needed in the system. We present a crowdsourcing marketplace that matches complex tasks, requiring multiple skills, to suitable workers. The key to ensuring high quality lies in skilled members whose capabilities can be estimated correctly. To that end, we present auction mechanisms that help to correctly estimate workers and to evolve skills that are needed in the system. Crowdsourcers do not need to predefine exact prices but only maximum prices they are willing to pay since the actual rewards for tasks are formed by supply and demand. Extensive experiments show that our approach leads to improved crowdsourcing, in most cases.

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1. Introduction

Crowdsourcing is a new paradigm for performing computations in Web-based environments by utilizing the capabilities of human workers. The idea of crowdsourcing is sometimes referred to as *human computation*, a methodology that lets humans process tasks which are difficult to implement in software. Such tasks include transcription of documents, reviewing of articles or evaluating the quality of ranking algorithms.

A major problem with current crowdsourcing environments as described in [1,2] is the lack of manageability as a result of the openness of Web based platforms, where anybody can join and participate. Whilst this openness, which allows to reach out to and attract members with different knowledge and interests, is an advantage of crowdsourcing, it is at the same time the reason that makes quality assurance particularly challenging. The crowdsourcing trend attributes partly to the success of outsourcing in general. With ever changing requirements,

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in-house business processes need to adapt to changing situations rapidly in order to stay competitive. Often, changes involve not only the need for process adaptation, but also, require an additional inclusion of new capabilities and knowledge, previously unavailable to the company. Hence, outsourcing of parts of business processes are an attractive model. Today, quality control in crowdsourcing often comes down to manually submit identical jobs multiple times to a crowd of workers. This, however, is only feasible for simple low-priced tasks and is in conflict with highly automated business process execution.

Apart from the fact that only very simple tasks are crowdsourced today, there is another major difference between crowdsourcing and task delegation in enterprise environments: the mapping of tasks to workers processing them. In enterprises tasks are usually directly assigned to employees while in crowdsourcing tasks are booked voluntarily. Workers are loosely coupled to the crowdsourcing platform compared to employees, and consist of heterogeneous members with different interests, working style, cultural background, and skills. Workers may join and leave at any time. This heterogeneity and freedom make it hard to ensure quality. A crowdsourcing task usually consists of a textual description and some reward. Workers can browse online through the list of published tasks and choose the ones they like. For crowdsourcers it is very hard to determine a reward that motivates workers to book the task but is not too high, either. This does not only depend on the task itself but also on external factors, e.g., number of available workers and the workers' context including social environment and environmental influences, like weather.

Nevertheless, crowdsourcing is pushed by large IT companies such as Amazon, Google, or Yahoo!. They have recognized the opportunities behind such *mass collaboration systems* [3] for both improving their own services and as business case. In particular, Amazon focuses on a task-based crowdsourcing platform called *Amazon Mechanical Turk* (AMT) [4]. Requesters are invited to issue *human-intelligence tasks* (HITs) requiring a certain qualification to the AMT. These crowdsourcers post mostly simple tasks that, however, require human capabilities. In particular, 50% of tasks are processed at a cost of $0.10 and less, most of the tasks are usually also offered in chunks to multiple AMT workers [5].

Our approach helps to establish crowdsourcing in a business environment. There are already providers that target at enterprise crowdsourcing, such as CrowdFlower [6] who broker crowd resources to customers to overcome quality and reliability issues. However, automated quality assurance and managing and adapting the crowd in an automated manner remains challenging. Crowd customers prefer fully automated deployment of their tasks to a crowd, just as in common business process models. In this paper, we propose a solution suitable in combination with the service-oriented architecture (SOA) paradigm. SOAs are an ideal grounding for distributed environments. With their notion of the participants as services and registries, resources can be easily and even automatically discovered for composing whole business processes. A plethora of standards supports seamless integration and registration of new services, and provides protocols for communication, interaction and control of the components. Altogether, we believe SOAs together with automated crowdsourcing of tasks provide an intuitive and convenient technical grounding to automate large-scale crowdsourcing environments. Important to note, today SOA not only includes software-based services, but also *Human-Provided Services* [7] and *BPEL4People* [8] for human interactions in business processes and allow to express mass collaboration environments.

This paper proposes to use auctions to map tasks to workers in the crowd. Thus, rewards for tasks are built based on supply and demand; crowdsourcers do not have to "guess" a fair, competitive reward, but may define a maximum amount of money they are willing to pay. This prevents from overpaying or underpaying; the latter may be equally bad and result in "non-sellers" with the potential to cause delays, e.g., in the context of business process execution. The auctioning mechanism does not blindly look at prices only, but includes several techniques to ensure quality. In addition to the pure mapping of tasks to workers we address how to build and manage an automated crowdsourcing platform. For establishing a successful crowdsourcing environment it is important to maintain a motivated base of crowd members and provide stimulus for learning required skills. Only a recurring, satisfied crowd staff is able to ensure high quality and high output. A *skill evolution* model supports new and existing crowd workers in developing capabilities and knowledge needed by crowdsourcers. All standard processes in the crowdsourcing platform are automated and free from intervention, which allows to handle a vast amount of tasks and makes it compatible with a SOA approach. To ensure sustainability, the model is designed to not only maximize the benefit of crowdsourcers, but also takes the welfare of workers into account. The main contributions of this work are:

- *Automated matching and auctions.* For providing a beneficial distribution of tasks to the available resources we organize auctions taking into account price and the suitability of workers estimated based on generated user profiles.
- *Stimulating skill evolution.* In order to bootstrap new skills and unexperienced workers we provide skill evolution by integrating assessment tasks into our auction model.
- *Evaluation.* Extensive experiments covering various scenarios quantify the advantages of a skill evolution based approach in comparison to traditional auctions.

This paper extends previous work presented in [9] mainly by providing a much more detailed discussion of our approach including relations to other work. The evaluation focus of the previous work is on a crowdsourcing marketplace with only one relevant skill, which refers to a highly specialized platform. Here, we specifically focus on environments where multiple skills need to be taken into account, as necessary in more general, business-oriented crowdsourcing.

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