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Crowdsourcing Information Systems – A Systems Theory Perspective

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Abstract

Crowdsourcing harnesses the potential of large and open networks of people. It is a relatively new phenomenon and attracted substantial interest in practice. Related research, however, lacks a theoretical foundation. We propose a system-theoretical perspective on crowdsourcing systems to address this gap and illustrate its applicability by using it to classify crowdsourcing systems. By deriving two principal dimensions from theory, we identify four fundamental types of crowdsourcing systems that help to distinguish important features of such systems. We analyse their respective characteristics and discuss implications and requirements for various aspects related to the design of such systems. Our results demonstrate that systems theory can inform the study of crowdsourcing systems. The identified system types and the implications on their design may prove useful for researchers to frame future studies and for practitioners to identify the right crowdsourcing systems for a particular purpose.

Keywords

Crowdsourcing, systems theory, crowdsourcing systems, crowd services, information systems

INTRODUCTION

Crowdsourcing denotes a variety of approaches that harness the potential of large and open crowds of people. A crowd usually emerges as an undefined network of people that responds to an open call for contribution to a particular task (Howe 2009). Organisations issue such calls with the purpose of benefitting from a much wider scale of inputs, information and capabilities. Crowdsourcing is increasingly performed via the Web, which enables the interaction with a plurality of contributors all over the world (Davis 2011). Dedicated information systems that integrate human and computational agents facilitate the process of sourcing and aggregating contributions from the crowd. These systems are called crowdsourcing systems and form a significant boundary-spanning object between an organisation and its environment. However, while the crowdsourcing phenomenon has been widely studied by means of exploring various case studies, these supportive crowdsourcing systems have been largely ignored by the IS research community.

Albeit a fairly new topic in scientific research, crowdsourcing systems have been used in practice since the emergence of Web 2.0 and in a multitude of different contexts. Various studies have been published in the last couple of years that seek to improve our understanding of crowdsourcing by delineating it from related phenomena and analysing its various manifestations. To this day, however, there is a general lack of theoretical background. As a consequence, designers and users of crowdsourcing systems have no guidance available to systematically comprehend the relevant properties of a variety of crowdsourcing systems. In order to address this problem, we propose to perceive crowdsourcing as an approach to further align the organisation as a system with its environment and to seek ways of benefitting from the input of elements and systems external to the organisational system. Accordingly, the *aim of this paper* is to address this gap by introducing a system-theoretical perspective on the characterisation and differentiation of crowdsourcing systems. In particular, we are addressing the following *research questions*

- What are the different types and services of crowdsourcing systems from a system-theoretical viewpoint?
- What are the resulting requirements and implications for the design of these systems?

Based on related work, we first establish a framework to describe the design of crowdsourcing systems. We analyse the existing body of literature for classification schemes that characterize relevant aspects and integrate them into this framework. We then use systems theory in order to derive theory-informed dimensions that enable us to distinguish four fundamental types of crowdsourcing systems. After exploring the characteristics of these four systems and identifying the distinct services that they provide to a crowdsourcing organisation, we discuss the consequences of this theory-guided perspective with respect to particular design questions. We conclude by summarizing the results of our work and describing potential implications.

RELATED WORK

Doan et al. (2011) define a crowdsourcing system as a system that "enlists a crowd of humans to help solve a problem defined by the system owners". In order to solve the problem, the system needs to address a number of fundamental challenges: deciding on the type of contributions that users can make, recruiting and retaining users, combining contributions to solve the problem, and evaluating users and their contributions. These challenges correspond well with a study by Malone and Laubacher (2010) on the building blocks or "genes" of collective intelligence systems. This leads to four basic design questions important for any system of collective action:

- "What is being done?" refers to the contributions that the crowd can make,
- "Who is doing it?" refers to the nature of the crowd,
- "Why are they doing it?" refers to incentives and motivation of the crowd,
- "How is it being done?" refers to the process of aggregating and evaluating contributions.

Existing literature in crowdsourcing and closely related fields often deals with classifying aspects relating to one or several of these design questions. This chapter discusses the relevant distinctions for each question. The discussion below shows that many of the classifications focus on a particular domain or address specific aspects. Most derive their differentiations mainly from an empirical analysis of existing crowdsourcing examples. To the best of our knowledge, there is no theoretically grounded perspective on crowdsourcing systems.

What is being done?

Doan et al. (2011) identify four basic roles that users can take in a crowdsourcing system. First, contributors can provide different perspectives, e.g., in the form of reviews or predictions. Second, they can provide self-generated content such as videos, images, or texts. Third, the contributors themselves can function as components of a system, e.g., by interacting in a social network or by forming a user community. Fourth, humans can be used as workers towards solving problems in a divide-and-conquer approach. A similar view on the nature of tasks that users can contribute is found in Corney et al. (2009), who distinguish between creation, evaluation, and organisation tasks.

According to Doan et al. (2011), several factors define the range of user contributions to a crowdsourcing system: the cognitive demand and the impact of a contribution, the complementary relationship with machine contributions, and a user interface that enables the easy provision of input. Further inspiration can be drawn from Zwass (2010), who in addition to the intellective demands of a task also considers its structural complexity, the effort intensity, and the time frame. One-dimensional classification schemes often focus on the first two issues – intellective demands and structural complexity – or build an abstract aggregate of the aforementioned factors. Schenk and Guittard (2011) distinguish simple tasks such as short text translations, complex tasks such as solving specific problems, and creative tasks such as logo design. Similarly, Rouse (2010) differentiates between simple (e.g., contributing product ideas), sophisticated (e.g., developing software), and moderate tasks (e.g., designing t-shirts).

Who is doing it?

The nature of the contributors in a crowdsourcing system correlates strongly with the characteristics of the tasks performed. Rouse (2010) states that simple tasks, on the one hand, can be done with moderate education and training. Sophisticated tasks, on the other hand, may require substantial domain knowledge and business acumen. Focusing on outsourcing labour to the crowd, Corney et al. (2009) distinguish tasks that anyone can perform (e.g., image-tagging), tasks for most people (e.g., rating certain products), and expert tasks, which require specific abilities, specialisations, or skills. A similar distinction of performers is employed by Zwass (2010), which includes the world, i.e., any individual, community members, skilled contributors, and prequalified individuals.

From a slightly different perspective, Geiger et al. (2011) explore the mechanisms that crowdsourcing organisations can employ to preselect the crowd of potential contributors. They distinguish between qualification-based and context-specific preselection. In the former case, potential contributors must demonstrate their abilities before being allowed to participate, which results in a crowd of skilled contributors. In the latter case, only certain individuals can contribute in a meaningful way, e.g., if they can provide opinions on a certain experience or if they belong to a specifically targeted customer group. This corresponds to the notion of prequalified individuals in Zwass (2010).

Why are they doing it?

Doan et al. (2011) list five major recruitment strategies in crowdsourcing systems: require users to contribute by authority, pay users, ask for volunteers, make contributions a requirement to use a different service, or piggyback on established systems. Considering the nature of a potential payment, Corney et al. (2009) identify contributions rewarded at a flat rate and contributions rewarded with a bonus or prize (in addition to voluntary contributions). This corresponds to Geiger et al. (2011), who distinguish between no, fixed and success-based remuneration.

Doan et al. (2011) also discuss a number of encouragement and retainment schemes, e.g., providing instant gratification, an enjoyable experience, or a way to establish a reputation. Zwass (2010) contains an extensive list of the most frequent motivators for contributors, from altruistic desires to monetary rewards. Rouse (2010) builds on Leimeister et al. (2009) and suggests seven motivations: self-marketing, social status, instrumental, altruism, token compensation, market compensation, personal achievement and learning. In a study on worker motivation on Amazon Mechanical Turk, Kaufmann et al. (2011) develop a theory-based model that differentiates between five groups of motivational factors: enjoyment-based motivation, community-based motivation, immediate payoffs, delayed payoffs, and social motivation. Several further studies have been performed on the motivation of contributors in specific crowdsourcing domains, e.g., idea contests (Leimeister et al. 2009), stock photography (Brabham 2008), t-shirt design (Brabham 2010), or micro tasks (Schulze et al. 2011).

How is it being done?

Almost any crowdsourcing system needs to process a multitude of contributions to fulfil its design purpose. Schenk and Guittard (2011) provide probably the most fundamental distinction of aggregation processes in crowdsourcing: integrative versus selective crowdsourcing. Integrative crowdsourcing creates value by pooling potentially large quantities of complementary input. Selective crowdsourcing creates value by having the crowd provide a set of options from which the result is chosen.

Doan et al. (2011) discuss how to combine individual user contributions and the degree of manual effort involved. They broadly differentiate between loose combination with little effort (e.g., numeric ratings), tight combination with substantial effort (e.g., merging code in software development), and no combination at all (e.g., merely listing textual reviews). Zwass (2010) lists a number of more specific alternatives for the "principal mode of product aggregation" including searchable corpus, hyperlinking, progressive refinement, statistical ratings and rankings, competitions and voting, information markets, folksonomies, and moderators, auditors, and facilitators. Doan et al. (2011) further distinguish an explicit and an implicit nature of collaboration, which defines whether contributors are aware of their collaboration with others or not. For the case of explicit collaboration, Geiger et al. (2011) describe different levels of accessibility that contributors are granted on other contributions: viewing, assessing, or even modifying each other's contributions. Finally, Doan et al. (2011) discuss some general techniques to manage malicious users by blocking them from entering the system, detecting them manually or automatically, and deterring them with threats of punishment.

As this overview about related work shows, there is no shortage of possible classifications of crowdsourcing systems. However, without a sound theoretical foundation it remains difficult to put crowdsourcing systems into a wider context and to precisely distinguish these systems on a set of well-defined attributes. In the following, we will introduce and deploy system theory as a way to develop a better understanding of the different facets of crowdsourcing systems.

A SYSTEMS THEORETICAL PERSPECTIVE ON CROWDSOURCING

As crowdsourcing means tapping into inputs from outside the conventional boundaries, it is perceived as useful to conceptualise the external actors contributing to crowdsourcing as belonging to a system that is external to and interacts with an organisational system. Based on the types of interaction between these two systems, distinct types of crowdsourcing can be differentiated. As such, we will provide a brief introduction to systems theory in order to establish the main constructs that are required for such a conceptualisation.

A system is composed of interrelated elements and has well-defined boundaries (Ackoff 1971; Kast and Rosenzweig 1972). These elements can be either homogenous (identical properties and behaviour) or heterogeneous. Elements are either internal and make up the system or they are external and part of the system environment when they can affect the state of the internal system. Systems that are interrelated with external elements and impacted by these are called open systems. The elements of a system, the interrelationships between them and the resulting behaviour of the system often lead to emerging properties, i.e., system characteristics that go beyond the sum of all elements.

Organisations are complex man-made systems that are dynamic, i.e., the state of an organisational system changes over time. Unlike technical (engineering) systems, which often have a well-defined (mechanical) and predictable reaction to external changes, organisations are responsive systems. A responsive system is exposed to environmental changes (the stimulus) and has decisive capabilities to select an appropriate response. As such, the system is a co-producer. Finally, organisations are goal-seeking systems and have a choice of behaviour. As purposive systems they aim to utilise its emerging properties and seek super-additive (or variety increasing) behaviour.

The study of organisations from a systems perspective is very advanced. Prominent manifestations of a closed system design paradigm are Enterprise Systems that comprehensively capture the elements and system-internal relationships of an organisation. They are, however, largely disconnected from external elements. The requirement to design more adaptive and responsive systems has motivated more recently the design and deployment of inter-organisational systems (e.g., supply chain management, e-commerce, and customer relationship management systems). Most of these systems are concentrated on transactional, predictive behaviour and are rather restrictive in the way the interrelationships between the system and its environment are implemented. Social media and also crowdsourcing systems form an entire new set of inter-organisational systems as the relationships are far less transactional and predictive, and the set of external actors is unknown and of high scalability.

It is proposed to use the introduced system-theoretical foundations to conceptualise crowdsourcing systems as one way to increase the responsiveness of an organisational system. By inviting a significant number of external elements to establish a relationship with the organisational system and by consciously designing a high openness of the system for such external inputs, a higher number of stimuli are produced. These stimuli can be utilised as valuable input for a number of business processes that require such inspirations, solutions or validations from the outside.

In order to classify the variety of crowdsourcing systems, we utilise two system-theoretical classifications. First, we will distinguish between crowdsourcing systems that treat the external elements as homogenous versus those that explicitly seek the participation of heterogeneous elements (i). Second, we will distinguish between crowdsourcing systems that seek and value each relationship with an external element, and the related stimulus, versus those systems that explicitly aggregate the stimuli across external elements in order to seek emerging or superadditive values (ii).

(i) A crowdsourcing system that treats all external elements as homogeneous and their stimuli as being identical in value follows a pure quantitative approach. Examples are organisations seeking external input for the execution of well-defined homogeneous activities such as digitizing x handwritten paper forms or organisations seeking validations based on votes. In these cases, each stimulus from an external element is used as long as it complies with the specifications. In contrast, a crowdsourcing system requiring heterogeneous stimuli has a higher emphasis on the individual qualities of the contribution. In this case, the single stimuli often compete with each other. This could be either in a race for the right solution (e.g., finding a lost billionaire using Google Earth) or they could be compared with each other (e.g., in an ideas contest). The former requires an absolute assessment, the latter a relative assessment, which leads to the second differentiation.

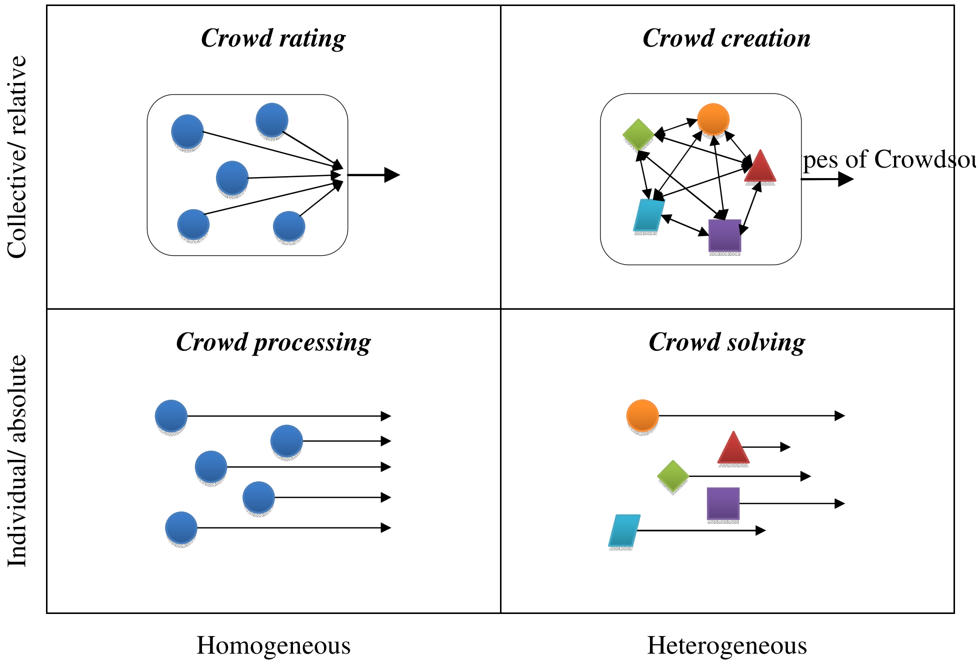
(ii) A crowdsourcing system may strive to benefit from an emerging property resulting from the 'system of stimuli' or it may benefit from each contribution in isolation. Systems that do not rely on an emerging property will judge each stimulus in isolation. This could be a well-defined input such as digitizing a number of forms, or an input that tries to solve a posted problem. In this case, the utility (or correctness) of the input can be judged in isolation and criteria for the assessment of the input do exist in advance. Systems, however, that try to harvest the superadditive value of all stimuli will need to consolidate all inputs. Examples could be a voting scenario or a design competition. In these cases, the stimuli can only be judged collectively or in relation to each other. In crowdsourcing systems that rely on the emerging property, there is typically no conception of what constitutes a good result.

FOUR TYPES OF CROWDSOURCING SYSTEMS

The combination of these identified two system-theoretical dimensions yields four different types of open crowdsourcing systems. Every type represents a prototypical system that provides a distinct service to a crowdsourcing organisation. We call this a crowd service and label the four systems individually. Similar to a software or digital service, a crowd service enables an organisation to realize a specific category of tasks by use of a crowdsourcing system. Figure 1 illustrates the four types of systems and their distinct services.

Crowd processing systems make use of large quantities of homogeneous external stimuli without aiming for an emerging property. These contributions are independent of each other and can be evaluated individually. The scalability provided by a crowdsourcing solution is utilized here to get tasks done quickly and efficiently by applying a divide and conquer approach. The purpose of such systems is to combine individual contributions to deliver a correct solution or result for the given task. The core service provided is access to additional bandwidth. Examples for such systems are Camclickr, Galaxy Zoo, Recaptcha, TxtEagle, and many more.

The perception of the crowd as a service provider as we use it here is probably most prominent in the context of such systems. Especially the idea of using human brainpower as a processor to solve problems that computers cannot (efficiently) solve has recently been gaining in importance in the field of human computation (Law and von Ahn 2011). In this context, Davis (2011) introduces the term crowdservicing. He focuses on the mostly automated integration of human and computational agents to achieve high levels of service quality by combining what each of the two can do best. The idea of integrating human and software-based services in service-oriented architectures is also described by Schall et al. (2010). Kern et al. (2010) use the term human-based electronic services to denote the utilization of human capabilities to mechanically process small tasks.



Crowd rating systems also rely on large quantities of homogeneous contributions, but actively seek the value of an emerging property. Unlike crowd processing systems, contributions are not evaluated individually but rather in a collective way. Using statistical approaches, contributions are aggregated to a collective response to the given task providing, e.g., a spectrum of opinion or collective assessments and predictions that reflect the "wisdom of crowds" (Surowiecki 2005). There is no a priori right or wrong result in such systems. Every contribution represents a specific vote; the scalability of crowdsourcing enables obtaining increasingly accurate results. Such systems are used, for example, to collect reviews (TripAdvisor, eBay reputation system), in online opinion panels (eRewards), or on prediction markets (Hollywood Stock Exchange, crowdcast).

Crowd solving systems, in contrast, apply a more qualitative approach using heterogeneous stimuli that represent (parts of) solutions to a specific problem. Similar to crowd processing systems, the external elements in crowd solving systems are evaluated individually on basis of objective and well-defined criteria. For this reason, the evaluation can even be automated in some cases. The goal of such systems is to get as close as possible to the best solution. The crowd solving process can terminate when the (best) solution is found (e.g., decoding a riddle). Every additional contribution potentially increases the quality of the results, a phenomenon which some people refer to as the "wisdom in the crowd" (Bessis and Xhafa 2011). A prominent example for this type of system is the Netflix Prize, another one is FoldIt.

Crowd creation systems are also based on a variety of heterogeneous external elements. The crucial difference to crowd solving systems is that contributions cannot be evaluated in isolation but need to be put in relation to each other. Evaluation criteria may be fuzzy and not well-defined or emerge only when comparing a collective of elements. Since there is no theoretically best or predictable solution, the goal of these systems is to produce a 'good' or satisfying outcome to a task. The variety of contributions increases with size and diversity of the crowd. Examples include all kinds of user-generated content systems (YouTube, the Yahoo! Contributor Network), design and ideation platforms (99designs, ideaBounty), or Wikipedia.

As stated above, the described systems are prototypical ones that provide one distinct service. Many existing crowdsourcing projects are built on systems that provide a combination of crowd services, often combining quantitative and qualitative components. For example, most platforms used to generate ideas (Dell IdeaStorm), designs (Threadless, iStockphoto), or software (AppStore) complement the crowd creation service with a crowd rating service in form of a collective voting on the created items and/or a crowd processing service such as tagging the items. Furthermore, some data collection projects such as Emporis, a crowdsourced database for buildings, implement a crowd processing service to capture well-defined "hard" facts (technical building data, addresses) and complement these with additional, non-predefined information (pictures, trivia) by using a crowd creation service.

In general, the type of the required crowd services depends on the specific goals of a crowdsourcing project. Projects may appear similar to the outside although they are based on fundamentally different intentions. As a result, they vary in the crowd services they use and, thus, in the characteristics of the underlying crowdsourcing systems. An example for that are crowdsourced translation projects. If the goal of such a project is to simply get a quick translation, e.g., for on-demand translation using mobile devices (Liu et al. 2011), a crowd processing service with some kind of basic quality assurance will be used. If the goal, however, is to get a good translation for a productive purpose – as it is the case for, e.g., Facebook – a crowd creation service in combination with a crowd rating service may be used: Contributors propose different translations and vote for the best one among all available alternatives.

DISCUSSION

We will now focus on the implications and requirements for the design of crowdsourcing systems based on the system-theoretical differentiation and the characteristics of the identified services. This discussion will be guided by the four design questions that have been explored in the related work part and the corresponding differentiations in the literature. Table 1 provides an overview of the design questions for the four types of crowdsourcing systems.

What is being done?

Depending on the type of service that a crowdsourcing system needs to perform, the role of contributors and the characteristics of the contributions that they can make differ substantially. Contributors in a crowd processing system take the role of workers or "slaves" (Doan et al. 2011) processing tasks in large quantities where the individual impact of a contribution is low. For this reason, the effort intensity of an individual task needs to be low, as are its structural complexity and the intellective demands (Zwass 2010). That is similar in most crowd rating systems, in which contributors act as perspective providers and value emerges only through the aggregation of a large number of these perspectives. This also implies low effort and complexity on the contributor side, although the intellective demand can be higher for predictive tasks that build on specific knowledge or experience.

By contrast, contributors in crowd solving and crowd creation systems act as providers of heterogeneous content. The impact of a contribution is potentially high, e.g., if it solves a problem or is chosen in a design contest. Crowd solving systems are designed around complex and intellectively demanding problems that require contributors to invest considerable effort. In crowd creation systems, these factors vary with the kind of content that contributors provide: complexity and effort intensity in software development, for example, are usually higher than in Wikipedia (Zwass 2010).

The diametrically opposed characteristics of the contributions in these different systems have implications on the design of ideal user interfaces and on the opportunities for coupling of human and computational agents. Crowd processing and crowd rating systems, on the one hand, need to provide user interfaces that facilitate the efficient contribution of input with low effort. Well-defined interfaces reduce the risk of structural variations in otherwise homogeneous contributions and enable a mostly automated evaluation. Computational services can be used in both types of systems to aggregate the collective input. User interfaces in crowd creation systems, on the other hand, must allow for higher degrees of freedom with respect to the contribution of heterogeneous input. Since contributions are evaluated relative to each other, computational services can only assist by facilitating the integration of human judgment, e.g., in the form of crowd rating services. Crowd solving systems, finally, also need to consider the open search space for potential solutions to complex problems. Ideally, however, they define clear and objective characteristics for simplified evaluation, which can then be supported by computational services.

Who is doing it?

Surowiecki (2005) states diversity, in terms of the various backgrounds that the members of a crowd possess, as one of the most important conditions for the "wisdom of crowds". As we explain in the following, diversity actually is a basic principle in every crowdsourcing system. The different system types vary in the ways that they benefit from the diversity of their crowd.

Crowd rating systems are based on the diverse knowledge and opinions that their contributors provide. This enables the aggregation of an accurate spectrum of opinion or the prediction of a certain outcome. Crowd creation systems seek to assemble a high variety of complementary or alternative contributions. The diversity of their contributors is a guarantor for this variety. In a similar way, many crowd solving systems rely on diversity to find increasingly better solutions to a given problem. Both types of systems are built on the premise that the "open call" (Howe 2009) to a large crowd, whose individuals possess diverse knowledge, experiences, and skills, will eventually turn up the right people. Crowd processing systems, finally, benefit from the diversity of interests within a crowd. This enables them to enlist contributors for many different tasks.

In order to ensure a high diversity, a system should consequentially keep the potential crowd of contributors as large and open as possible. Crowd processing systems with tasks that require only moderate education and training (Rouse 2010) are especially accessible. Their tasks often harness basic abilities of the human brain such as image or text recognition and can be performed by most individuals. Other systems – such as most crowd creation and crowd solving systems – may be focused on specific domains and will thus mainly attract contributors with the necessary knowledge and skills (Zwass 2010). Nevertheless, they should also allow for the serendipity of receiving high-quality contributions by amateurs or experts from different domains.

A system may be forced, however, to restrict participation to certain contributors. Sometimes, this is a way to ensure a certain level of quality. It can also be required due to privacy concerns when working on knowledge-intensive tasks (Geiger et al. 2011). Further restrictions of the crowd may be necessary depending on the context of the system or its task. Some crowd rating systems, for instance, require contributors to be familiar with a particular item, issue, or domain.

Why are they doing it?

People participate in crowdsourcing activities for a variety of reasons. Many crowdsourcing projects realize similar goals with different incentives using payment, social motivation, altruistic motives, or even games to name but a few. The choice of proper motivational factors depends on the particular task and its context, which is the object of a multitude of studies (Antikainen et al. 2010; Brabham 2008; 2010; Leimeister et al. 2009; Paolacci et al. 2010). Some general observations and guidelines, however, can be made with respect to the type of service that is performed by a crowdsourcing system.

Due to their usually large demand for homogeneous contributions, crowd processing systems either need to be very persuasive in asking for volunteers, develop a clever way to piggyback on other systems or games (e.g., von Ahn and Dabbish 2008; von Ahn et al. 2008), or simply pay for contributions (Doan et al. 2011). Kaufmann et al. (2011) study worker motivation on Amazon Mechanical Turk and find that payment presents indeed the most important motivation, closely followed by several other factors that relate to enjoyment-based motivation. Since tasks are homogeneous and usually of the same size, contributions are rewarded at a flat rate per completed task. On Mechanical Turk, for example, this results in an hourly wage of $1.38/hour (Horton and Chilton 2010).

For most other crowdsourcing systems, fixed payment is not an appropriate option. In crowd rating systems, it might incentivize people to make arbitrary contributions, thereby distorting the collective results. While this is true for all crowdsourcing systems that are based on homogeneous low-effort contributions, crowd processing systems can apply various mechanisms for spam detection (Kern et al. 2010) since contributions can individually be checked for correctness. Crowd rating systems, however, are based on a collective evaluation of contributions and there is no 'correct' result. In most cases, they need to establish non-monetary incentives. Crowd rating systems that are used to predict a specific outcome may also employ a success-based remuneration (Geiger et al. 2011). If and how much individual contributors to such a system are paid depends on the deviation of a prediction from the actual outcome. Some prediction markets such as the Iowa Electronic Markets employ this mechanism indirectly through varying share value.

Success-based remuneration is also a wide-spread incentive in most crowd solving and crowd creation systems. In qualitative crowdsourcing systems that rely on heterogeneous external elements, every contribution is valued differently. A fixed payment is pointless and would discourage sophisticated and time-consuming contributions. Contributors therefore need to be payed differently depending on the objective or relative value of their input. Success-based payment provides a better option in these cases and increases the overall quality of contributions by setting the right incentives.

How is it being done?

In order to create value, a crowdsourcing system needs to aggregate the external stimuli that are contributed by the crowd. Based on Schenk and Guittard (2011), a system can perform an aggregation in an integrative or a selective way, depending on its specific goal and the type of contributions. Systems that rely on homogeneous elements, i.e., crowd processing and crowd rating systems, always perform an integrative aggregation. Contributions on a task in such systems are valued identically and, thus, have an equal part in the final outcome. For this reason, the degree of manual effort that is required to perform the aggregation (Doan et al. 2011) is in most cases relatively low.

By contrast, systems with heterogeneous external elements, i.e., crowd solving and crowd creation systems, are based on the premise that individual contributions and their values are distinct. These systems can perform an integrative aggregation, in which case the individual contributions complement each other, e.g., by contributing different aspects to a task. They can also employ a selective aggregation by comparing the values of individual contributions, based on objective or subjective criteria. Especially when heterogeneous contributions are combined or when they are judged in relation to each other, the degree of manual effort involved is considerably higher than in systems with homogeneous contributions.

In addition to manual aggregation by the system owner or (semi-)automated aggregation by computational services, some systems can also rely on crowd-based support to perform a certain degree of aggregation. In crowd creation systems with their need for comparative and subjective evaluation of input, one possibility is the use of crowd rating services. This can take different forms such as voting on individual contributions to determine collective favourites (Bao et al. 2011) or reporting contributions that do not correspond to the defined standards. Another possibility besides this "crowd assessment" (Geiger et al. 2011), is to allow contributors to directly modify each other's contributions and, thus, merge individual input. A good example for the latter is the Wikipedia system where contributors incorporate their input directly into the existing body of knowledge, which, in turn, is an aggregate of individual contributions.

Table 1. The design of crowdsourcing systems.

	Crowd processing	Crowd rating	Crowd solving	Crowd creation
What is being done?	Large quantities, no individual differences Effort intensity, structural complexity and intellective demands of each task is low	Large quantities, no individual differences Effort intensity and structural complexity of each task is low Intellective demand higher for specific predictions	Quality/ uniqueness of contribution, possibly a high individual impact Complex and intellectively demanding problems requiring considerable effort Well-defined problem	Quality/ uniqueness of contribution, possibly a high individual impact Problem can have a loose definition, often creative in nature
Who is doing it?	Diversity important to enlist contributors	Diversity important to increase accuracy	Diversity important to find the best solution	Diversity important to increase variety
Why are they doing it?	Payment, volunteering, or piggybacking (e.g. game)	Fixed payment not an appropriate option, success-based possible for predictions	Success-based remuneration, fixed payment not a good option Every contribution valued differently, drives quality of contributions	Success-based remuneration, fixed payment not a good option Every contribution valued differently, drives quality of contributions
How is it being done?	Perform an integrative aggregation, mostly little manual effort needed	Perform an integrative aggregation, mostly little manual effort needed	Integrative or selective aggregation Can (partly) be automated computationally	Integrative or selective aggregation Manual effort needed; can (partly) be crowdsourced (e.g. rating)

CONCLUSION

The purpose of this paper is to provide a theoretically grounded perspective on crowdsourcing information systems. Existing classifications of crowdsourcing systems are derived mainly from empirical analysis of crowdsourcing examples in use and, thus, lack theoretical foundation. By applying systems theory to the context of crowdsourcing systems, we were able to derive theory-informed dimensions that distinguish four fundamental types of crowdsourcing systems. We identified the distinct services that each of the prototypical systems can offer to crowdsourcing organisations and analysed their respective properties. Based on the individual characteristics of these systems we discussed the consequences for particular design questions.

There are two main implications to our results. First, this paper demonstrates that systems theory can inform the study of crowdsourcing systems. Future research should build on this theoretical foundation to gain further insights and deepen our understanding of crowdsourcing approaches. Second, the four identified types of crowdsourcing systems and their distinct services provide a framework for future research into specific system properties. In connection with the discussed implications and requirements for system design, this may also help practitioners to identify the right crowdsourcing system for a given purpose.

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APPENDIX: CLASSIFICATION SCHEMES FOR CROWDSOURCING

What is being done?	
(Doan et al. 2011)	*Role of human users:* slaves, perspective providers, content providers, component providers
(Corney et al. 2009)	*Nature of the task:* creation, evaluation, organisation
(Doan et al. 2011)	*Factors that define what contributions users can make:* cognitive demand, impact of a contribution, potential machine contributions, user interface
(Zwass 2010)	*Task characteristics:* structural complexity, intellective demands, effort intensity, time frame
(Schenk and Guittard 2011)	*Type of tasks:* Simple, complex, creative
(Rouse 2010)	*Nature of the task:* simple, sophisticated, moderate
Who is doing it?	
(Rouse 2010)	*Supplier capabilities:* moderate education and training vs. substantial domain understanding and highly developed business acumen
(Corney et al. 2009)	*Nature of the crowd:* any individual, most people, experts
(Zwass 2010)	*Performers:* the world, prequalified individuals, community members, skilled contributors
(Geiger et al. 2011)	*Preselection of contributors:* qualification-based, context-specific, both, none
Why are they doing it?	
(Doan et al. 2011)	*How to recruit and retain users:* require users by authority, pay users, ask for volunteers, make users pay for service, piggyback on the user traces
(Corney et al. 2009)	*Nature of the payment:* voluntary contribution, rewarded contribution at a flat rate, rewarded contribution with a bonus or prize
(Geiger et al. 2011)	*Remuneration for contributions:* fixed, success-based, none
(Doan et al. 2011)	*Encouragement and retainment schemes:* provide instant gratification, enjoyable experience, necessary service, or ways to establish a reputation; set up competitions; create ownership situations
(Zwass 2010)	*Motivation:* list of most frequent motivators
(Rouse 2010)	*Forms of motivation:* self-marketing, social status, instrumental, altruism, token compensation, market compensation, personal achievement and learning
(Kaufmann et al. 2011)	*Motivational factors of workers:* enjoyment-based motivation, community-based motivation, immediate payoffs, delayed payoffs, social motivation
How is it being done?	
(Schenk and Guittard 2011)	*Nature of the process:* integrative vs. selective
(Doan et al. 2011)	*How to combine user contributions:* not at all, in a loose fashion, tightly
(Doan et al. 2011)	*Degree of manual effort*
(Zwass 2010)	*Principal mode of product aggregation:* searchable corpus, hyperlinking, progressive refinement, statistical ratings and rankings, competitions and voting, information markets, bottom-up taxonomy (folksonomy), moderators, auditors, and facilitators
(Doan et al. 2011)	*Nature of collaboration:* explicit vs. implicit
(Geiger et al. 2011)	*Accessibility of peer contributions:* none, view, assess, modify
(Doan et al. 2011)	*How to evaluate users and contributions:* block, detect, deter

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