NoQueue, a crowdsourcing queue management application

C. E. Stoica, L. A. Toader, and G. V. Stoica

***Abstract*—**Crowdsourcing is a form of collaboration evolved under Web 2.0 that helps in finding efficient solutions to current problems by public participation of actors, i.e. crowd, using mass spread technologies as Internet, mobile devices, social media. In this paper we analyze the challenges that a crowdsourcing developer faces and we propose a solution for the queue management problem based on the NoQueue application.

***Keywords*—**Crowdsourcing, collaboration, queue management.

I. Introduction

THE Internet evolution can be classified into two distinct stages: the Web 1.0 with the focus on restricting the access to data for its own gain and artificial price increase within the famous dot-com boom, and the Web 2.0 when the more valuable information is as it is widely used [1]. In this new Internet, the information or code of a software program is no longer strictly controlled internally, but is available for change by anyone, leading to the birth of open source software. Surprisingly, with this approach, costs are reduced and at the same time the quality of the product is superior. Through this model, tasks normally performed by employees are outsourced to the crowd within the Internet, i.e. *crowdsourcing*.

In this paper we discuss about the types of collaboration over Internet, describe current and past paradigms from dedicated collaboration and computer supported work solutions to mass collaboration, and propose a solution for the queue management problem based on crowdsourcing - NoQueue application.

II. Computer Supported Collaborative Work

Computer-supported cooperative work supports human interaction by combining the social and technical demands to groups sharing a common identity and/or a common goal [2]. Starting as a solution to overcome space and time limitations or various fields of interests to solve common problems, computer supported collaborative work projects evolved from dedicated specialized architectures for private or individual interests to today human interaction on public platforms [10].

III. Crowdsourcing

The *crowdsourcing* term, invented by Jeff Howe in 2005, emerges from the observation that important companies from various domains start externalizing important activities to Internet groups of peoples and take advantages from masses to develop new products or services through collective intelligence and using new technologies like blogs, podcasts, forums, social networks, mobile platforms [1].

A. Types of crowdsourcing

Depending on how the crowd is gathered and the tasks to be done, Jeff Howe defines four major categories of crowdsourcing:

1) Collective intelligence or intelligence of the masses. This is one of the most common types and involves gathering a set and creating conditions for it to provide its knowledge. Examples range from very simple, such as employee suggestion boxes, to global brainstorming sessions, facilitated by the Internet, in large companies such as IBM. Starbucks and Dell use idea management systems taken from groups of customers. There are also companies that use groups of people with scientific expertise to solve complex technical problems [3]. Also included in this category are innovative user-driven methods where companies use the ideas of the most important users of their products to improve their products or design the next generation of products [3].
2) Collective creation. Compared to collective intelligence, through collective creation a company appeals to its own users to create or co-create a new product or service. This concept involves dividing creative activity into small pieces that can be done by people in their free time. An important example is the Mechanical Turk from Amazon, where people can perform small tasks. Amazon now has more than 100,000 workers in more than 100 countries within the platform [3].

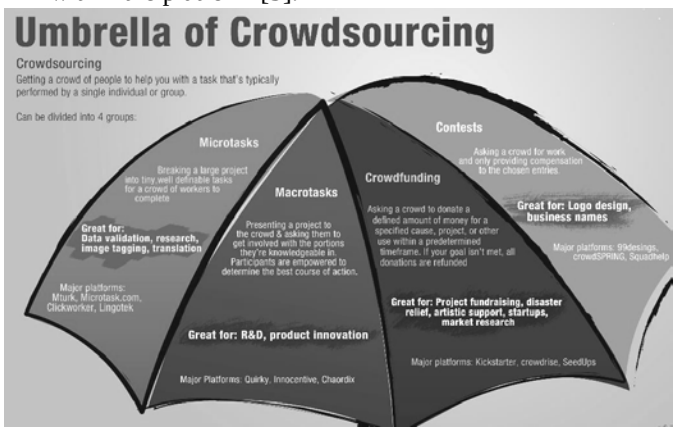

Fig. 1 The crowdsourcing umbrella [7]

3) Crowdvoting. This type of crowdsourcing uses the masses to organize the huge amount of information. Often, it is used alongside the first two types listed above to organize and filter the huge number of resulting contributions. The crowd vote began to see an increase in use in market predictions, being used as an internal tool for companies to predict sales. Even the search results on Google start from an algorithm based on the popularity of the sites, that is, the result of the vote of the crowd [3].
4) Crowdfunding. The Internet has allowed sites to appear where people can borrow small amounts to fund projects of great diversity, giving rise to platforms such as Kickstarter, which encompass over 10 million contributors or Indiegogo, a crowdfunding platform with over 15 million users more than 200 countries. People in need of funding range from singers who are trying to launch their creations, ambitious technology engineers, or entrepreneurs with a niche business. Through crowdfunding, innovation can be achieved without constraints and without resorting to traditional funding methods that could impose restrictions on projects [3]

B. Key ingredients

In order to be able to achieve results through crowdsourcing, it is advisable to follow good practice [3].

Choosing the right crowd. It is important to understand that only a small part of the crowd will actively participate, often around 1 per cent. Thus we need to start from a large enough number of people to get accurate and consistent results. Also, individual thinking should not be suppressed by group thinking, because the crowd's vote and collective intelligence will be severely affected. The reason is the dependence of crowdsourcing on random and widely distributed contributions as knowledge that can only come from a wide variety of people. It is difficult to obtain valid solutions for technical problems without having in the group people with the right expertise in the field.

The right motivational factor. Individuals within the group need a strong motivation to perform at a high level, and money is not always the solution to get a strong or an active community. The financial reward must be supplemented or replaced by other motivating factors such as attractive tasks, recognition of work and assuming responsibilities. One of the challenges of crowdsourcing is finding the perfect mix of motivating factors to get the expected results.

Crowdsourcing is not a panacea. Often, a person trying to use crowdsourcing to develop their business discovers that it is at least as difficult and costly as the traditional choice of employers. Crowdsourcing is extremely useful if it can be implemented at the same cost in time and money as it will lead to more creative ideas simply by the fact that there is a net number of contributing people. It is important to remember that extracting ideas for every business will take a lot of time and money to be able to successfully control the crowd's contributions.

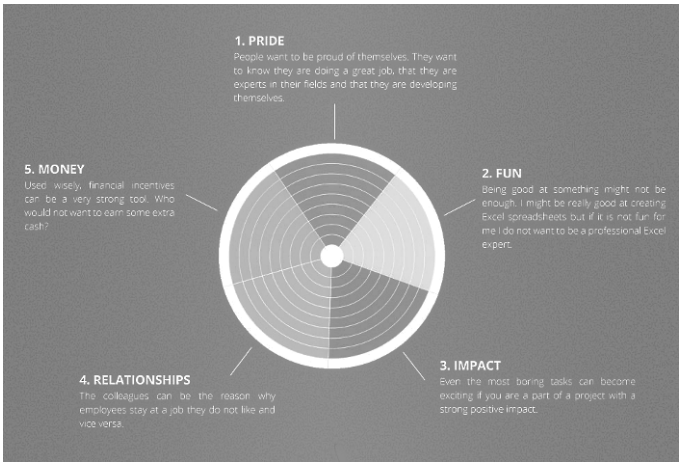

Fig. 2. Motivational factors [8]

Sense of direction. Starting from the previous point, the crowd's contributions must be strictly controlled, which requires significant resources. In order to successfully build a community, people need to feel appreciated, this being an important part of their compensation for their efforts. In order to keep the crowd in the desired direction, it will be necessary to take a coordinating position, providing advice and help whenever it is needed.

Divide et imperta. In order to rely on crowdsourcing, complex tasks must be divided into simple tasks and then distributed. Among the most successful businesses based on crowdsourcing were those that relied on the work of amateurs who were satisfied with a modest financial reward (e.g. iStockphoto). Thus, in order to attract the crowd, the tasks must be simple and fun enough to be carried out in their spare time.

The community is always right. The business model that uses crowdsourcing can not work with a top-down (top-down) management and organization style, just as complete anarchy is not a viable solution. Once a community is formed, the set of rules changes from a traditional organization. Thus, it is the optimal method of leadership that takes into account the opinion of the community.

Real purpose for the crowd. Crowdsourcing works because it caters to the top of Maslow's needs pyramid. That is why, by participating in the project, the community has to meet needs such as creativity, spontaneity, problem solving, and last but not least, the need for membership.

IV. Crowdsourcing Systems Over Internet

A crowdsourcing system is defined as a system in which a lot explicitly collaborates (e.g. Wikipedia, Linux) or implicitly (like ESP, a game in which users label images as a side effect of participation) to get a finite product useful to the entire community and with an extended life span. Since this definition excludes systems such as Mechanical Turk, where a finished product is not actually made and there is no actual community, a crowdsourcing system is, in a generalized fashion, any “system that makes use of a lot of people to solve

a problem defined by system owners" [4].

It becomes obvious that any project can gain from the use of crowdsourcing and the steps are very simple: the problem is described on the Internet, users contribute and contributions are analyzed to develop a solution.

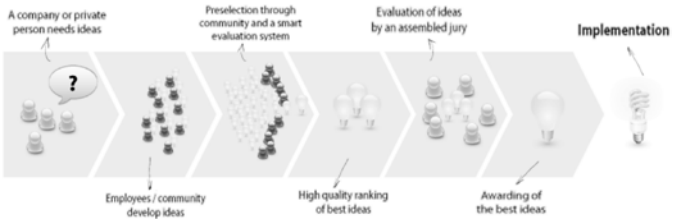

Fig. 3. The crowdsourcing process [9]

A. Explicit clowdsourcing systems

These are independent systems that allow direct collaboration of users who can evaluate, share, socialize, build finished products or perform tasks. We can identify several types of explicit systems as presented below [4].

Evaluation. This includes systems that let users evaluate things like movies, music, restaurants, comments, notes, or other ratings. One of the most important examples is Yelp, a site that allows the assessment of any business or institution that offers a service, such as restaurants, bars, hospitals, beauty salons, or car services.

Sharing. Systems to share services, knowledge or products are included. Among the systems that can share knowledge are Yahoo! Answers, eHow or stackoverflow. The systems that share products or services are Youtube, SoundCloud, Instagram or Pinterest. These systems allow the dissemination of knowledge and content of any type at an unprecedented rate and in a way accessible to anyone with Internet access.

Social. These are systems that allow users to build a large social chart by adding friends, knowledge, and other types of content. Once built, this graph of knowledge and friends can be used to get benefits such as job offers or advertising.

Product build. Here are systems that enable a product to be made by aggregating and modifying user contributions, and they are themselves the ones who perform this aggregation and modification. Notable examples include the development of software products such as Linux and Apache, or the building of online knowledge bases (Wikipedia) where users contribute information in the form of text, images or web pages and then analyze and combine contributions. The success of Wikipedia's online encyclopedia has encouraged the emergence of other specialized knowledge bases such as EcoliHub, which stores all known information about E.coli bacteria.

Task fulfillment. Here are systems that enable various types of tasks to be accomplished, from looking for missing persons to the search for celestial bodies and their appointment or classification of various types of data. In order to allow crowdsourcing to be applied to a task, it is necessary to identify the components that fit this model, more precisely to find the portions of the task to which it can contribute individually and then aggregate the contributions to obtain the desired result.

B. Implicitly clowdsourcing systems

There are systems that implicitly encourage collaboration to solve a problem. They fall into two categories: stand-alone and dependent [4].

Stand alone. This type of system provides a service that has the secondary effect of collaborating users to solve a problem. As an example, the ESP game involves the guessing of words describing an image and by which, as a side effect, those images are tagged. The event prediction sector takes advantage of user bets on the outcome of various events, ranging from election to sports events, and aggregates users' predictions to make predictions. The premise is that collective intelligence is often accurate and using user information can increase prediction accuracy. A platform that successfully uses the default collaboration is IMDB (The Internet Movie Database). This allows its users to add movie titles to their personal accounts, and encourages them to rate those movies by offering the opportunity to find all the movies in a category that have a particular note, or by providing personalized recommendations based on the videos uploaded to the account.

Dependent. This type of system takes advantage of other systems to fulfill its function. Many dependent systems have been based on the most popular search engines (Google, Bing), using information such as search history or clicks to fulfill a wide range of tasks, from spell check and grammar to finding synonyms, or prediction of epidemics. There are also examples of systems that use user purchase history to make personalized product recommendations.

V. Chalenges And Solution For Crowdsourcing Applications

The main challenges of a crowdsourcing system include:

Attraction and retention of users. This dilemma is one of the most difficult to solve, but the possibilities are multiple. First, users may be required to contribute if there is authority (a boss may ask his employees to contribute to a project). An alternative would be the recruitment of volunteers, a solution that enjoys great popularity because it is easy to implement and more importantly, free of charge. The disadvantage is the inconsistency with which users are recruited. Another solution is simply financial compensation of users for contributions to the system. This solution often does not provide sufficient motivation for users to achieve quality work. The last solution is to exploit information from other systems. For example, a spell-and-grammatical correction system can use user searches from a popular search engine.

Types of contributions that users can make. The ways in which users contribute to crowdsourcing systems are limited and simplistic, since the tasks they are required to perform are the smallest possible work unit in which the system can be

divided. There are also crowdsourcing systems of a high complexity, in which the possibilities of contributing the users are much more diverse. The challenge is to design the system to maximize the range of contributions and to find the optimal solution, consider the following factors: contributions intellectual complexity, impact, software contributions, system interface.

Aggregators. Any crowdsourcing system must implement an effective way to combine user contributions. In most cases, aggregation is poor, as in assessment systems, where reviews are not aggregated, but only user notes or social networks that only link contributions (friendships) to form a social graph. Systems of increased complexity such as knowledge bases or games require a much stronger aggregation. A major problem arises in the case of conflicting users' contributions, namely choosing how to deal with these conflicts. There are both manual and automatic solutions to this problem. Automated, aggregated weighted user contributions based on user rating criteria. Thus, the more reliable a user is, the higher his weight and the end result heavier influenced by his contribution. By contrast, manual solutions let solving the conflict at the discretion of users.

Evaluating users and their contributions. Although crowdsourcing systems have many advantages, and users are often in good faith, it should also be taken into account by malicious users that could affect the proper functioning of the system. One method of prevention is to limit the types of contributions a user can make. This allows all users to contribute with information, but only certain users will be able to filter and aggregate the data to get the final result. By using trusted users, any malicious contribution will be identified and removed, keeping the system running smoothly. Detection of malicious users can be done through several methods, both manual and automated. In the case of manual methods, the system is monitored by the owners, who in turn distributes the task of monitoring to a group of trusted users, and ordinary users are co-opted to draw attention to malicious contributions. Automatic methods calculate the credibility of the user through questions that the answer is already known to. A malicious user will intentionally misinterpret these questions, and the system will detect its destructive intentions. In contrast to malicious users, those users that are positively highlighted can be recommended by other users and rewarded. These can be remarked by system owners and used to positively influence the rest of the community or to run ad campaigns. Despite all these methods of preventing negative contributions, some of them will still get into the system. Therefore, there is a need for a method by which the system can identify and eliminate negative contributions before they can affect the proper functioning of the system. The effectiveness of the method greatly depends on the degree of aggregation of contributions, making it very easy to remedy the problem if there is no aggregation of contributions, such as a review system and very difficult to remedy if these contributions are vital to the system and affect other parts of it.

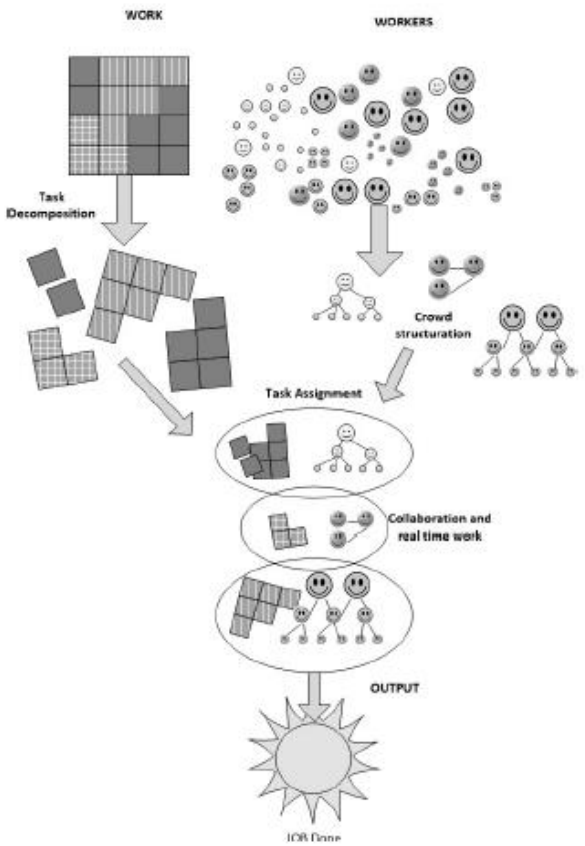

Fig. 4. Tasks distribution in crowdsourcing systems [27]

VI. Queue Management with NoQueue

People, especially those in urban areas, lose a significant amount of time in queues for various services. Waiting for queues has become a frequent occasion, especially in developing countries and cities with increased population density. An increased waiting time may cause some customers to quit the service and move towards competition. This has led to the emergence of queue management systems (QMS).

A. Queue Management System

A queue management system promises to reduce waiting times and increase customer satisfaction by using cameras, various sensors and interactive kiosks to determine factors such as the length of queues. Using the information gathered, the system can predict waiting time at any time and produce statistics on which the company or institution can take measures to avoid overcrowding. Although queue management systems are a good solution for reducing waiting times, they are primarily targeted at companies and institutions, and users only benefit indirectly. In addition, such a system entails large deployment and maintenance costs and requires the construction of a location-specific infrastructure, starting costs of around $ 200 / month per location and easily reaching over $ 1000 / month per location. For example, when using cameras and image analysis algorithms, the problem of optimal cam placement appears to minimize errors. Also, in the case of agglomeration, some rooms can be locked and so a larger

number of rooms is needed to ensure system operation in all conditions. Moreover, these rooms lead to intimacy problems, and the algorithms used for image analysis are of high complexity and are sensitive to daytime lighting conditions [5]. The emergence of smartphone and mobile internet has allowed unprecedented access to information. Anyone who has a smartphone with Internet access can now look through the collective knowledge base of mankind and receive real-time responses. In this context, crowdsourcing can use your smartphone and any other smart devices with Internet access as a mobile platform for collecting user contributions. At the same time, users can benefit from the crowdsourcing-based system from wherever they are and at any time. Thus, it has become possible to develop a real-time queue management system based on crowdsourcing. Users are the central component, providing data that the system processes, and then providing predictions and statistics back to users. Such a system can be implemented relatively easily and with minimal costs, the infrastructure being already made available as smart-held devices, and the communication channel is represented by the Internet.

In order to have a queuing management system based on crowdsourcing that is functional, certain conditions must be met. First of all, there must be enough users who are willing to provide information on the waiting time and the number of people in the queue. Second, the frequency with which contributions are received must be large enough to allow credible predictions to be generated. Last but not least, the accuracy of user estimates must be good enough, otherwise predictions and statistics will be unusable. In a study in which such a crowdsourcing system was implemented, it was estimated that approximately 7% of users were willing to contribute estimates. Given a sufficient number of users, this contribution rate was sufficient to generate usable data. Obviously, a larger number of contributions will lead to an increase in prediction accuracy, but it has been proven that users have lower precision when queue size is higher [5].

Another problem is the quality of data provided by users. Because they work with human beings, the data contributed is often subjective. Thus, users tend to overestimate the wait time when they are behind the tail and underestimate the waiting time when they are more in front of the queue. This is due to the user's emotions during the expectation, which is pessimistic when it is at the beginning of the waiting period and there is a large number of people in front of it and becoming optimistic as it advances towards the end of the waiting period. Knowing this subjectivity allows the application of statistical corrections that improve the quality of predictions.

In conclusion, crowdsourcing queuing management systems can be used successfully and have good enough accuracy.

B. Queues management with the NoQueue application

The application has a modern architecture, using the capabilities of the Java EE 7 platform on the back end and versatility of the AngularJS on the front end. Compared to a traditional architecture where the emphasis is placed on the server side, the client side takes on a part of the server's responsibilities, being built as a Single Page Application and interacting with the REST server.

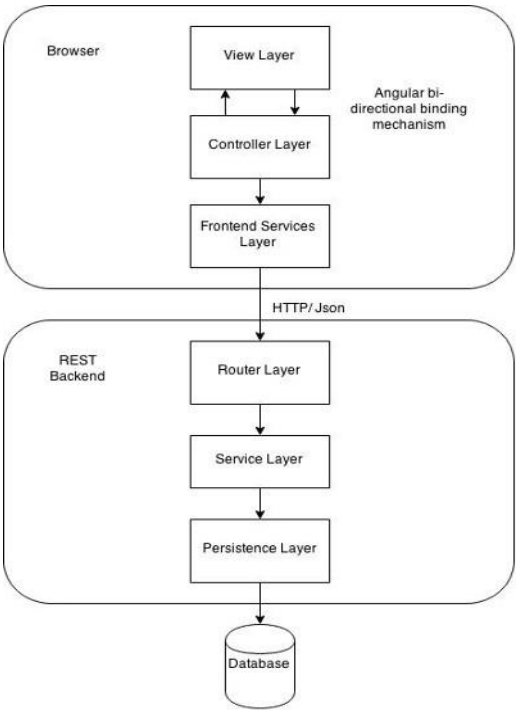

Fig. 5. NoQueue application architecture

The NoQueue application is built on the Single Page Application (SPA) model and has a responsive design, allowing it to be used easily regardless of the device used and its resolution. The interface is predominantly geared towards mobile devices, with a simplified look that is suitable for touch navigation.

The application provides users with detailed information and statistics on the various waiting queues present within the system. Thus, the user can make informed decisions to reduce the time spent waiting for queues. The user can choose queues for which they want fast access without a pre-search by adding to favorites. As a side effect of using the app, waiting queues are reduced as people spread evenly over the entire work schedule of institutions and companies that form queues.

Fig. 6. NoQueue responsive with mobile oriented design

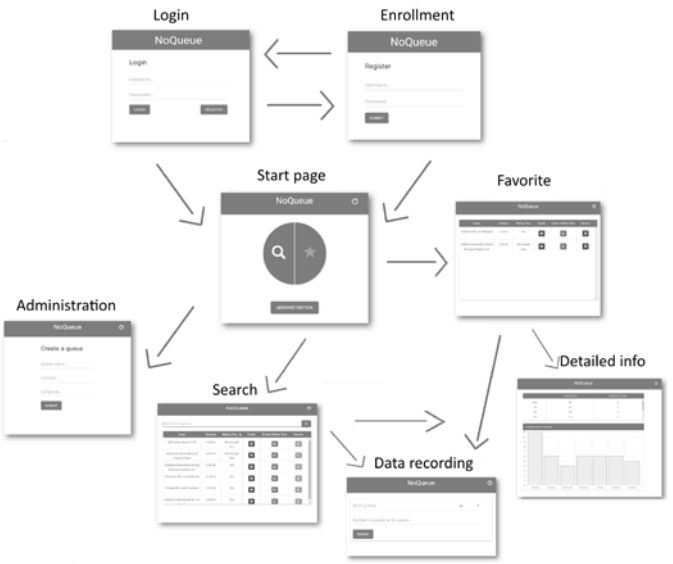

Fig. 7. NoQueue application usage diagram

VII. Conclusion

Collaboration is an intrinsic feature of human beings, being one of the main reasons we owe our success as a species. At first, collaboration was limited to a limited number of individuals in the vicinity. With the emergence of the possibilities of remote communication, such as the first postal service introduced by Babylonian King Hammurabi in 1700 BC [6], it became possible to collaborate over longer distances, but the lengths of time required for communication were great and the efficient organization difficult to achieve.

The modern age can be seen as one of globalization, and the Internet is the force of change. Communication has never been easier, making it virtually instantaneous regardless of the distances involved. The Internet has opened the way for unprecedented mass collaboration possibilities, which has allowed the emergence of a global collective intelligence. Through this collective intelligence, technological progress has been strongly accelerated and the way has opened for a prosperous future.

In 2006, the intelligence of the masses was used on such a large scale by big companies as well as by fresh companies, that a word was needed to describe it.

This paper was about studying crowdsourcing, a way in which a lot of people can be used to solve any task that fits into dividing into independent subunits. The power of collective intelligence is so great that virtually all major companies use it in one form or another. Crowdsourcing gave birth to some of the most popular and varied products like Linux, Youtube, Wikipedia, Mozilla Firefox or Waze, and the list is endless.

The success of the product depends both on the quality of the software and on the successful implementation of the principles of crowdsourcing:

1) Correct choice of the crowd. In the present case, there is no need for experienced people to perform complex tasks. The concept is suitable for people with varying levels of education, requiring only the introduction of simple data (waiting time, number of people in queue). The only requirement is the presence of a large enough number of users, given that the percentage of people contributing to such applications is on average 1%.
2) Motivativation. Given the negative implications associated with waiting queues, reducing the time spent in such queues is considered to be a sufficient motivating factor.
3) Project organization. Because user tasks are reduced to the introduction of simple data, the determination of waiting times for different queues is easy to divide into independent subunits and is thus suited to crowdsourcing.

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