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A general-purpose conceptual model for crowdsourcing projects

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Dissertação de Mestrado apresentada ao Programa de Pós-Graduação em Informática da Universidade Federal do Espírito Santo, como requisito parcial para obtenção do Grau de Mestre em Informática.

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"Never forget what you are, for surely the world will not.
Make it your strength. Then it can never be your weakness.
Armour yourself in it, and it will never be used to hurt you.
George R. R. Martin - A Game of Thrones"

Resumo

Crowdsourcing é um método que consistem em contratar pessoas para processar dados de entrada destinados a solucionar um problema computacional complexo, como gerar um grande *dataset* de imagens anotadas, transcrições de áudio ou descrições de cenas de vídeo. Nesta abordagem, pessoas solucionam tarefas e produzem resultados individuais, de acordo com uma lista de passos que os converge para uma solução eficiente. Então, cada resultado individual deve ser coletado, interpretado e integrado por uma plataforma ou sistema que suporte o processo de *crowdsourcing*. Considerando que os estudos iniciais sobre esta área de conhecimento foram feitos através de experimentos e observações relacionados à plataformas e sistemas que popularizaram o uso deste método, consequentemente, a contribuição destes estudos é proporcional ao que estas plataformas e sistemas oferecem e executam. Dito isto, questões pertinentes são: (i) além de plataformas ou sistemas, quais são os principais elementos que compõem um projeto *crowdsourcing*? (ii) Como guiar as pessoas passo-a-passo para solucionarem o problema proposto? (iii) Como garantir a qualidade dos resultados produzidos durante todas as etapas do projeto? (iv) Existem diretrizes ou modelos no estado-da-arte para auxiliar pessoas interessadas em criar este tipo de projetos? Visando responder estas questões, uma revisão da literatura baseada na visão de quem buscou solucionar problemas utilizando do método de *crowdsourcing* foi realizada durante esta dissertação de mestrado, constatando assim que este domínio carece de diretrizes e modelos que apresentem os principais elementos deste tipo de projeto, assim como suas relações e descrições. Portanto, este trabalho tem como objetivo apresentar um conjunto de tendências e diretrizes relacionadas a projetos *crowdsourcing* e propor um modelo conceitual genérico que represente os principais elementos envolvidos neste tipo de projeto e como estes se relacionam, de forma que possa ser instanciado e expandido para suprir necessidades de projetos específicos. No mais, o modelo proposto foi aplicado durante o planejamento e a execução de um projeto *crowdsourcing* realizado *in loco*.

Palavras-chave: *Crowdsourcing*, Projetos *Crowdsourcing*, Modelagem Conceitual, *Workflow*

Abstract

Crowdsourcing is a method that employs people to process input data to solve a computationally complex problem, such as generating a large dataset of annotated images, audio transcriptions or video scene descriptions. In this approach, people select tasks and produce individual results according to a list of steps that leads to an efficient solution. Then, every single result must be collected, interpreted, and integrated by a platform or system supporting the crowdsourcing process. Considering that the first studies regarding this field of study were done by means of experimenting and observing platforms and systems that popularized this method. Given that, pertinent questions are: (i) besides platforms and systems, what are the essential elements that compose a crowdsourcing project?; (ii) how the humans are guided through the steps for solving the proposed problem?; (iii) how to ensure the quality of the results produced in all stages of a project?; and (iv) are there guidelines or models in the state-of-the-art to help newcomers creating their own projects? Aiming to answer these questions, a systematic literature review based on the viewpoint of individuals that seek to solve problems using the crowdsourcing method was performed during this MSc dissertation, thus stating that this domain lacks general guidelines and models that leverage the essential elements of this kind of project, as well as its relationships and descriptions. Therefore, this dissertation aims to present a set of tendencies and guidelines related to crowdsourcing project and propose a general-purpose conceptual model that represent the essential elements involved and how they relate in this kind of project, in a way that is possible to instantiate and expand this model to supply specific needs of individual projects. Furthermore, the proposed model was applied during the planning and execution stages of a crowdsourcing project designed locally.

Keywords: Crowdsourcing, Crowdsourcing projects, Conceptual Modeling, Workflow

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List of abbreviations and acronyms

Mturk	Amazon Mechanical Turk
HIT	Human Intelligence Task
SMS	Short Message Service
GWAP	Games-With-A-Purpose
LPRM	Networks and Multimedia Research Laboratory
UFES	Federal University of Espirito Santo
BPMN	Business Process Model and Notation

Contents

1 Introduction

Some tasks, such as image recognition, are trivial for humans, but still challenging to even the most sophisticated computer programs. The human computation paradigm focuses on harnessing human time and energy for addressing issues that a computer cannot yet solve on their own. This paradigm considers human brains as processors in a distributed system, each performing a small part of a massive computation (VON AHN, 2005).

Crowdsourcing, in short, is a problem-solving method that applies the human computation paradigm in an organized way, by managing a crowd of contributors, to solve proposed problems (DOAN; RAMAKRISHNAN; HALEVY, 2011). This method is used primarily to process objects (e.g, image annotation and segmentation) and its results are applied in many fields of study, such as medicine, linguistics, machine learning, and multimedia.

By following a problem-oriented workflow, each member of the crowd works on a portion or on the entire problem, performing a human computation task that produces useful results towards the solution to the crowdsourcer's problem. Planning, coordination, and control of process are defined by a production manager, usually, the crowdsourcer, although some authors argue that the responsibility for workflow design can be shared between the crowd and the crowdsourcer (KULKARNI; CAN; HARTMANN, 2012).

Some authors say that crowdsourcing workflows are needed once they facilitate decomposing tasks into subtasks, managing their dependencies, and assembling the results (KITTUR et al., 2013; KULKARNI; CAN; HARTMANN, 2012; RETELNY; BERNSTEIN; VALENTINE, 2017). On top of that, our view of this concept is broader. The crowdsourcing workflow is context-oriented and should be composed of at least one or more task sets and one or more quality control activities to guarantee reliable results. These task sets and quality control activities can be executed in parallel, iterative, and sequential ways. In this sense, it is possible to set quality control activities before, during, or after the task execution stages, thus allowing the crowdsourcer to better understand how the quality will be managed during the project.

Hence, a crowdsourcing workflow should be unique for each project. It should represent the planning and coordination done by the crowdsourcer in the entire project, thus, representing a broader view of who will participate, what will be produced, and how it will be done at each stage of the workflow.

In known studies concerning the crowdsourcing domain, such as the works of Estellés-Arolas & Guevara (2012), Zhao & Zhu (2014), and Doan, Ramakrishnan & Halevy

(2011), the authors validate their assumptions by evaluating and comparing crowdsourcing platforms and systems, such as the Amazon Mechanical Turk (Mturk)[1], CrowdFlower[2], Innocentive[3], and Threadless[4]. These studies defined some essential concepts of the crowdsourcing domain, but their evaluations are focused on platforms and systems which only represents one of the essential components of a crowdsourcing project.

Given that, pertinent questions emerged, such as:

1. Besides platforms and systems, what are the essential elements that compose a crowdsourcing project?
2. How the humans are guided through the steps for solving the proposed problem?
3. How to ensure the quality of the results produced in all stages of a project?
4. Are there guidelines or models in the state-of-the-art to help newcomers creating their own projects?

Aiming to answer these and other questions, a systematic literature review based on the viewpoint of individuals that seek to solve problems using the crowdsourcing method was performed. This study provided us the knowledge to understand what is needed to obtain reliable results in a crowdsourcing project and helped us to define nine essential elements that are mandatory in this kind of project, which will be further discussed. Also, it stated that there are no widely adopted standards to help newcomers to understand, develop, and implement crowdsourcing projects.

Lukyanenko & Parsons (2012) stated that poorly defined projects usually lead to unnecessary costs and project failure. Given that, and considering that crowdsourcing is a recent field of study and the projects in this field relies on the context that they are being executed, it is still a challenge nowadays to define standards that cover crowdsourcing projects in general, which can be used to avoid the aforementioned issues.

According to Mylopoulos (1992), a conceptual model can be used to share a common view about a specific domain to newcomers, through a variety of graphic and linguistic interfaces. Also, a conceptual model is designed to be used by humans, not machines, and it is based on a formal notation which allows the understanding of the semantics related to a specific domain.

Furthermore, Olivé (2007) points out two types of conceptual schemes: (i) The structural schemes (e.g., a class diagram) specify entity types, relationship types, restric-

[1] mturk.com
[2] crowdflower.com
[3] innocentive.com
[4] threadless.com

tions and taxonomies, while (ii) behavioral schemes (e.g. an activity diagram) specify events in the domain state, as well the events that the system can perform.

Therefore, we consider that conceptual schemes, both structural and behavioral, can be used to define standards of how to plan and execute a crowdsourcing project.

However, Lukyanenko & Parsons (2012) also leveraged three issues to develop a conceptual model in the crowdsourcing domain:

1. "How can crowdsourcing conceptual models represent the diversity of views and accommodate a variable level of expertise?"(p. 3)

2. "How the crowdsourcing domain changes the role of conceptual models as a facilitator of user-designer communication?"(p. 3)

3. "What type of information should a crowdsourcing conceptual model specify?"(p. 3)

Therefore, aiming to define a reference model that captures a common view about this domain and help newcomers to plan and execute crowdsourcing projects in a proper way, this MSc dissertation seeks to design a general-purpose conceptual model for crowdsourcing projects, that follows the definitions proposed by Olivé (2007). Moreover, we aim to answer the issues leveraged by Lukyanenko & Parsons (2012).

1.1 Objectives

The general objective of this dissertation is to design a general-purpose conceptual model for crowdsourcing projects that represents a common view of this domain to newcomers.

To achieve the aforementioned general goal, we aim to accomplish the following specific objectives:

1. Define the essential elements that are mandatory in every crowdsourcing project, usign a systematic literature review of crowdsourcing projects as a knowledge base.

2. Specify the relationships among these essential elements and among other supplemental elements.

3. Summarize our findings and design them into a reference general-purpose conceptual model for crowdsourcing projects, which covers both the planning and execution stages of a project.

1.2 Organization

The rest of this text is organized as follows:

- Chapter 2 presents the theoretical background and related works, detailing the crowdsourcing method and the efforts to create conceptual models related to this domain.
- Chapter 3 shows the methods and results of a systematic literature review of crowdsourcing projects. This review, together with the Chapter 2, was used as a knowledge base to define the essential elements of crowdsourcing projects. Moreover, it presents a set of tendencies related to the crowdsourcing domain.
- Chapter 4 regards the design of a general-purpose structural conceptual model of crowdsourcing projects. This model is composed of three class diagrams, two of them representing the planning and execution stages of a project, respectively, and one unifying these two stages, thus representing a crowdsourcing project as a whole. Also, this Chapter presents how behavioral conceptual models can be used in this domain.
- Finally, Chapter 5 concludes this dissertation, leveraging our contributions, limitations, and future works.

2 Theoretical Background

This Chapter presents the theoretical background related to this work. In Section 2.1, we present the concepts of human computation. Section 2.2 discuss the state-of-the-art of the crowdsourcing domain. Lastly, in Section 2.3, we show the work related to crowdsourcing conceptual modeling.

This Chapter, alongside with Chapter 3, was used as a knowledge base to define the essential elements of crowdsourcing projects and the relationships among them.

2.1 Human Computation

The human computation paradigm defines that human contributors must work only on tasks that really require their attention, and this is done by dividing the tasks that require human intelligence, called HITs (Human Intelligence Tasks), from the tasks that can be done automatically by a computer. Hence, to achieve the effectiveness of the human computation paradigm, the computer must only execute tasks that require its attention, while the human contributors must only execute tasks that the computer cannot, or are extremely difficult to, solve in an automated way (LAW; VON AHN, 2011).

As this paradigm needs human effort to accomplish tasks, von Ahn (2005) also defined in his Ph.D. thesis that the contributors in a human computation approach must receive an incentive in order to become part of a collective computation. The incentives offered usually are extrinsic, such as monetary rewards paid to the contributors, or intrinsic, such as the entertainment used in the Games With a Purpose (GWAP), which provides HITs embedded with a gaming platform to be solved by the humans while playing the game, e.g., the ESP game (VON AHN; DABBISH, 2004).

Given that, we can state that crowdsourcing is a problem-solving method that applies the human computation paradigm in an organized way. In this method, computer science is important to guide a crowd of human contributors towards the solution of a proposed problem, by managing task executions, quality of results, and incentives offered.

2.2 Crowdsourcing

Howe (2006) wrote the first report about crowdsourcing in the information technology field of study, published in Wired Magazine[1]. This article compared a crowdsourcing

[1] wired.com

online platform called IStockPhoto[2], which collects and provides images from independent contributors, with the services offered by a professional photographer. As a conclusion, the author shows that the crowdsourcing platforms offered satisfactory images with a price 99% lower than the price offered by the professional photographer.

Howe (2008) stated the following description to define the crowdsourcing term:

> "Crowdsourcing is the act of taking a task traditionally performed by a designated agent (such as an employee or a contractor) and outsourcing it by making an open call to an undefined but large group of people. Crowdsourcing allows the power of the crowd to accomplish tasks that were once the province of just a specialized few."(p. 1)

However, the crowdsourcing field of study grew in popularity, and several researchers proposed new definitions for this term. In a popular publication, Estellés-Arolas & Guevara (2012) reviewed various crowdsourcing studies and proposed a unified description:

> "Crowdsourcing is a type of participative online activity in which an individual, an institution, a non-profit organization, or company proposes to a group of individuals of varying knowledge, heterogeneity, and number, via a flexible open call, the voluntary undertaking of a task. The undertaking of the task, of variable complexity and modularity, and in which the crowd should participate bringing their work, money, knowledge and/or experience, always entails mutual benefit. The user will receive the satisfaction of a given type of need, be it economic, social recognition, self-esteem, or the development of individual skills, while the crowdsourcer will obtain and utilize to their advantage that what the user has brought to the venture, whose form will depend on the type of activity undertaken."(p. 197)

Considering this definition, Estellés-Arolas & Guevara (2012) extracted eight characteristics and used them for analyzing crowdsourcing systems and platforms. These characteristics are listed below:

1. "There is a clearly defined crowd."
2. "There exists a task with a clear goal."
3. "The recompense received by the crowd is clear."
4. "The crowdsourcer is clearly identified."

[2] istockphoto.com

5. "The compensation to be received by the crowdsourcer is clearly defined."

6. "It is an online assigned process of participative type."

7. "It uses an open call of variable extent."

8. "It uses the Internet." (p. 197)

Yin et al. (2016) state that crowdsourcing platforms hide personal attributes and social characteristics of the participants. In these platforms, the communication usually is only in one direction: from the person asking for a solution (the crowdsourcer) to each participant individually (the worker). Hence, participants commonly are abstracted as merely black box ways to accomplish microtasks associated with the problem solution. However, other authors consider the communication in crowdsourcing as a two-way process, such as stated by Oleson et al. (2011), which asked for feedback from the workers to generate ground truth data (gold units). Furthermore, complex tasks require increased communication with the workers. However, as tasks become more complex, the relationship between the crowdsourcer and workers becomes more akin to outsourcing than crowdsourcing (STAFFELBACH et al., 2015).

The crowdsourcing domain has similar concepts with other ones, such as outsourcing, crowdfunding, and crowdsensing. A way to identify if a project belongs to the crowdsourcing domain is applying the conceptual framework proposed by Zhao & Zhu (2014), which was defined based on the design questions behind collective intelligence, presented by Malone, Laubacher & Dellarocas (2010). This framework is composed of four key questions that should be answered in every crowdsourcing project:

1. "Who is performing the task?"

2. "Why are they doing it?"

3. "How is the task performed?"

4. "What about the ownership and what is being accomplished?"

The first question is related to the composition of a crowd, which can be classified as a group of anonymous people or a group composed of specific people. The second question is about what incentives the workers to contribute to a crowdsourcing project, and according to Ryan & Deci (2000), these incentives can be intrinsic and reflect the natural human propensity to learn and assimilate, or they can be extrinsic and reflect external control or true self-regulation. The third issue relates how the tasks are executed, whether it will be divided into microtasks that compose a result by aggregating all microtasks result (e.g., Mturk), or the task will be realized by competitive means, selecting and rewarding the best results (e.g., freelancer[3]). Tasks can also be addressed by free contribution, allowing the workers to use their creativity and contribute to the project in their own ways, without following clear definitions. The last question is about the product generated, which is the result of a crowdsourcing project (ZHAO; ZHU, 2014).

Hosseini et al. (2014) identified four essential pillars of crowdsourcing: (i) The crowd pillar consists of workers that contribute with a crowdsourcing project; (ii) the crowdsourcer pillar is responsible for planning, coordinating, and controlling the crowdsourcing project; (iii) the crowdsourcing task pillar consists of the activities to be solved by the workers; and (iv) the fourth pillar refers to the crowdsourcing platform, which manages the crowd and the tasks.

Estellés-Arolas, Navarro-Giner & Guevara (2015) conducted a literature review searching for different crowdsourcing typologies. Then, they stated an integrated typology composed of five main types:

1. Crowdcasting: Competitive crowdsourcing initiatives, where a problem is proposed to the crowd and the worker who solves it first or do it better receive a reward.
2. Crowdcollaboration: Crowdsourcing initiatives in which communication occurs between workers of the crowd.
3. Crowdcontent: The crowdsourcer seeks crowd labor and knowledge to create or find content of various types but not in a competitive way.
4. Crowdfunding: When an individual or an organization seeks for funding from the crowd.
5. Crowdopinion: When the crowdsourcer seeks user opinions and validation about a particular issue or product through votes, comments, tags, or ratings.

As crowdsourcing is a general-purpose method, a common issue is how to classify crowdsourcing tasks. To address this issue, Brabham (2012) defined four categories of crowdsourcing tasks according to what problem these tasks address: (i) Knowledge Discovery and Management consist of tasks that find and collect information into a common location and format; (ii) Broadcast Search are tasks that solve empirical problems; (iii) Peer-Vetted Creative Production organizes tasks that create and select ideas; (iv) Distributed HITs are tasks that analyze a significant amount of information.

Alongside the previous categories of Estellés-Arolas, Navarro-Giner & Guevara (2015), Zhao & Zhu (2014), and Brabham (2012), Geiger et al. (2012) observed two dimensions related to crowd participation in crowdsourcing systems. The first dimension is

[3] freelancer.com

related to systems that seek homogeneous or heterogeneous contributions: a homogeneous system values all (valid) contributions equally, i.e., all the inputs are qualitatively equivalent. In another hand, a heterogeneous system values the contributions according to their qualities, i.e., all inputs are qualitatively different. The second dimension classifies systems that seek emergent or non-emergent values from the contributions: a non-emergent system generates its product by selecting satisfactory individual contributions, while an emergent system generates its product from the entirety of inputs and the relationship between them, i.e., aggregating the contributions and thus generating the crowd consensus.

Considering the aforementioned dimensions, Geiger et al. (2012) categorize the crowdsourcing systems in four types according to their crowdsourcing process and how their product is generated:

1. The Crowd Rating type classifies systems that receive massive homogeneous contribution and seeks to generate their product through aggregating and relating all contributions. The consensus between these collaborations provides a collective result, such as a spectrum of opinions or common assessments and predictions that reflect the wisdom of crowds.
2. Crowd Processing systems collect numerous homogeneous contributions and seek non-emergent value that derives from the individual contributions. These systems commonly use the microtask approach and aggregate all individual contributions of one microtask to generate a collective result, e.g., labeling images.
3. Systems that seek heterogeneous contributions and their products are derived from aggregations and relations between all contributions are classified as Crowd Creation systems. Each input is qualitatively different and aggregating these contributions must generate a comprehensive product, e.g., an image database.
4. Crowd Solving consists of systems that collect heterogeneous contributions and seeks non-emergent value from the individual contributions. Specific evaluation criteria define the qualitative value of each contribution. Workers on these systems present individual solutions to a proposed problem; then the product is generated by evaluating and selecting the best solutions.

A crowdsourcing process can be viewed as both collaborative or cooperative. Roschelle & Teasley (1995) defined two statements that demonstrate the difference between collaborative and cooperative work:

> “Collaboration is a coordinated, synchronous activity that is the result of a continued attempt to construct and maintain a shared conception of a problem.”(p.70)

> "Cooperation is accomplished by the division of labor among participants as an activity where each person is responsible for solving a portion of the problem."(p.70)

A crowdsourcing collaborative process, collaborators usually have a broad view of the entire process and frequently rely on the communication and contributions of other participants to realize their work, such as in the Idea Jam[4] and Ushahidi[5] approaches. In another hand, a crowdsourcing cooperative process usually is controlled by a human computation algorithm, in which workers contribute individually, and applied to solve a problem proposed, sponsored by a crowdsourcer and hidden from the workers, as in the Mturk platform.

Considering that this study is focused on defining crowdsourcing projects in a general way, some important concepts such as the number of workers and contributions, synchronization, and other execution details that can influence in some, but not in all, projects were considered out of the scope of this study.

2.3 Crowdsourcing Conceptual Modeling

Aiming to find studies related to crowdsourcing and conceptual modeling, we did a systematic literature review for conceptual/user models and crowdsourcing in five knowledge bases relevant for the computer science field of study, as shown in Table 1, using the following query string:

crowdsourc AND ("conceptual model*" OR "user model")*

Table 1 shows the number of papers found in each knowledge base using the query string mentioned above, until May 2018. The Filtered Total represents the number of papers after aggregating them and removing call-for-papers and duplicates.

The first filter applied in this systematic review was reading the title and abstract of the papers and verifying if their main focus is in conceptual modeling the crowdsourcing process. After applying this filter, 10 of the 60 scientific papers were selected to be completely evaluated.

Some authors entitled their findings as conceptual models, such as in (PEDERSEN et al., 2013; CUPIDO; OPHOFF, 2014; ZAKARIAH; JANOM; ARSHAD, 2016; LENART-GANSINIEC, 2017). However, their findings did not consent with the definitions proposed by Mylopoulos (1992) and Olivé (2007). Hence, in our understanding, the diagrams

[4] ideajam.io
[5] ushahidi.com

Table 1 – Papers related to crowdsourcing conceptual modeling found in the digital libraries

Knowledge Base	Total
ACM Digital Library	20
Engineering Village	43
IEEE Xplore	14
Science Direct	03
Scopus	59
Filtered Total	60

presented in these works cannot be considered as conceptual models. Therefore, only two models emerged from our systematic review.

Legitimate crowdsourcing conceptual models are the ones presented in the works of Bozzon et al. (2014), which modeled crowdsourcing scenarios in socially-enabled human computation applications, and in the work of Barbosa et al. (2014), which modeled crowdsourcing conceptual models for generic e-learning tools.

As a result of this systematic review, we can affirm that there is no conceptual model that represents crowdsourcing projects in a general way and follows the conceptual foundations and standards defined in the software engineering state-of-the-art (e.g., conceptual or behavioral schemes). Hence, we aim to design a general-purpose conceptual model that provides detailed information about crowdsourcing projects to newcomers and also highlights the main concerns that the crowdsourcer should consider when designing a project in this domain.

3 Understanding Crowdsourcing Projects

To understand how the crowdsourcing projects should be properly designed, we realized a systematic literature review of indexed papers (ASSIS NETO; SANTOS, 2018) that presented the implementation and execution of this kind of projects. In this Chapter, we present methods, results, and findings of this systematic literature review.

3.1 Methods

The methods used in the review for filtering and selecting scientific papers are based on the taxonomies and classifications given by the works mentioned in Section 2.2.

3.1.1 Research questions

At first glance, our systematic review seeks to understand how crowdsourcing projects are reported by the scientific community. To fulfill this purpose we designed the following research questions:

- (RQ1) What are the tendencies related to crowd management, platforms used, and task types in crowdsourcing projects?
- (RQ2) What are the limitations of general-purpose platforms used in crowdsourcing projects?
- (RQ3) How is quality managed in the crowdsourcing projects?

3.1.2 Selecting crowdsourcing projects

Considering that the characteristics proposed by Estellés-Arolas & Guevara (2012) were defined with the purpose of analyzing crowdsourcing systems, we compared and contrasted these features with the conceptual framework proposed by Zhao & Zhu (2014). As a result, we selected four criteria which were used to evaluate the crowdsourcing projects in our study: (i) crowd composition; (ii) incentives for workers; (iii) tasks execution; and (iv) final product.

Estellés-Arolas & Guevara (2012) concluded that a crowd is composed of a group of individuals with the characteristics of size, heterogeneity, and knowledge determined by each project. Therefore, we considered the framework proposed by Zhao & Zhu (2014) for classifying the crowd used in each project as anonymous or specific, allowing us to separate projects that provide worker information to the crowdsourcer (specific crowd) to the projects that don't provide worker information (anonymous crowd).

We didn't consider that the use of the Internet in crowdsourcing projects is mandatory because it is possible to use other communication means, as presented in the work of Gupta et al. (2012) and in the Ushahidi platform. These platforms use Short Message Service (SMS) communication, instead of using the Internet in their crowdsourcing process (ASHLEY et al., 2009).

According to previous discussions, we choose to use the four following criteria to filter and select crowdsourcing projects in our research:

1. What is the crowd composition?(Anonymous or Specific)
2. What are the incentives offered?(Intrinsic or Extrinsic)
3. How the tasks are performed?(Defined Task, Competitive Task, or Free Contribution)
4. What product is generated at the end of the project?

Different from Brabham (2012) that seeks to classify crowdsourcing tasks according to what is being accomplished, we established four categories of tasks, inspired by the classification of crowdsourcing information systems proposed by Geiger et al. (2012).

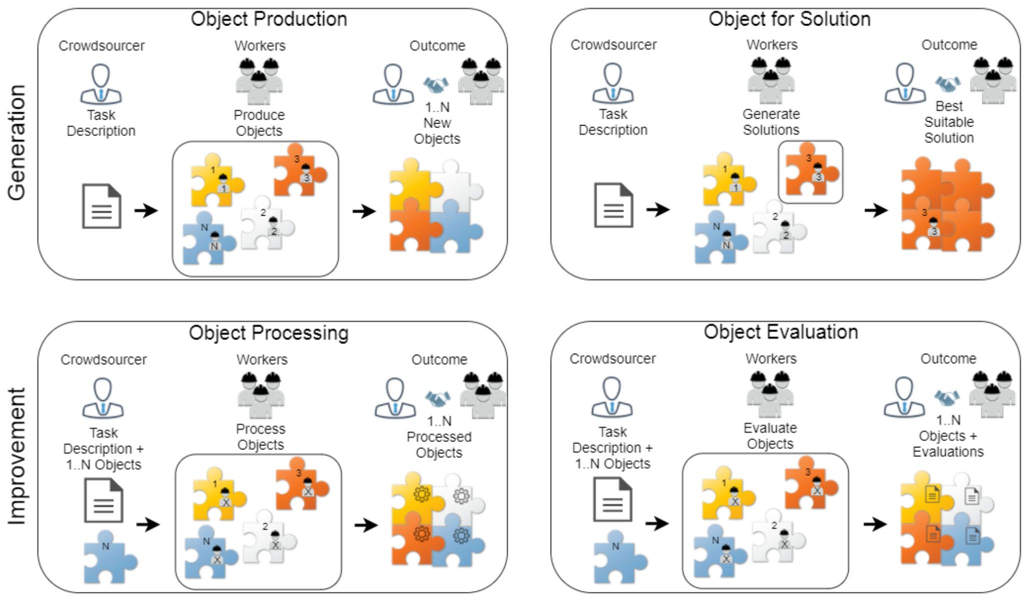


Figure 1 – The four types of crowdsourcing tasks (ASSIS NETO; SANTOS, 2018)

Figure 1 shows the four categories of crowdsourcing tasks proposed in our review. This description was used to evidence three essential matters in the tasks: (i) What is provided by the crowdsourcer when designing a task; (ii) how the crowd works in a task; and (iii) what is the outcome of a task.

These four types of crowdsourcing task presented in our review are described as follows:

1. Object Production: The crowdsourcer gives a task description requesting that the workers produce objects, each worker generates one or more objects, and the outcome is a set of new objects created by the workers.

2. Object for Solution: The crowdsourcer describes a problem and requests workers to generate solutions, the workers individually produce solutions, and the outcome is the best suitable object that solves the given problem.

3. Object Processing: The crowdsourcer gives a set of N objects to be processed by the crowd, the workers process the objects according to the task description, and the outcome can be a set of objects edited by the workers or the given objects alongside a set of new metadata generated by the crowd.

4. Object Evaluation: The crowdsourcer gives a set of N objects to be evaluated by the crowd, the workers assess the objects according to the task description, and the outcome will be the given objects alongside a set of evaluations related to these objects.

Hence, we divided these four task types into two dimensions:

1. Generation: This dimension classifies task types that the crowdsourcer gives a task description and request that the workers generate objects or solutions for a proposed problem. Each object created in these tasks represents the work of a single worker.

2. Improvement: This dimension classifies task types that the crowdsourcer gives a set of N objects alongside the task description. Each object processed or evaluated in these tasks represents the work of X workers.

3.1.3 Query string

Aiming to find papers that approach platforms, systems, or applications in crowdsourcing and then highlight articles that focus on planning and applying crowdsourcing projects, we formulated a query string that includes variations of the term crowdsourcing along with systems and platforms, including the terms jobs or tasks. We excluded from our string the terms crowdfunding, crowdsensing, and papers that focus reviews and surveys. Therefore, our query string is defined below:

(crowdsourc) AND (platform OR software OR application) AND (job OR task) NOT (crowdsensing OR crowdfunding OR survey OR review)*

This query string was executed on the following digital libraries: (i) ACM Digital Library. (ii) Engineering Village. (iii) IEEE Xplore. (iv) Science Direct. (v) Scopus. These libraries were selected because of their relevance to the field of computer science, and their content is accessible to the authors during this review.

Papers are selected as the result of a match between the query string and their title/abstract/keywords, this research was realized until Oct. 2016. The query string was adapted according to the requirements of each digital library.

3.1.4 Inclusion and exclusion criteria

Papers that fit in the following criteria were selected for further review:

- (INC1) Papers that mainly focus crowdsourcing.

  Rationale: A considerable number of articles use crowdsourcing to compare results or to complement purposes on other fields of study.

- (INC2) Papers that present planning and execution of crowdsourcing projects.

  Rationale: Evaluating crowdsourcing projects allows a broad view of the crowdsourcing process.

- (INC3) Indexed papers.

  Rationale: To guarantee some degree of quality in our study, we selected only indexed articles to further review.

- (INC4) Papers that were written in English or Portuguese.

  Rationale: For reasons of feasibility, articles written in another language were excluded.

Papers that fit in the following criteria were discarded:

- (EXC1) Short Papers.

  Rationale: We considered that the papers should have at least four pages to be suitable for our review process.

- (EXC2) Criteria proposed by evaluating the definitions of Estellés-Arolas & Guevara

(2012) and Zhao & Zhu (2014). These criteria were presented in the section 3.1.2.

Rationale: The authors consider that these characteristics are essential to defining if a project fits in the crowdsourcing field.

- (EXC3) Crowdsourcing projects inexistent or poorly defined.

  Rationale: The primary focus of our study is to understand the crowdsourcing process as a whole. Therefore, it's essential to evaluate well-defined projects.

- (EXC4) Similar papers.

  Rationale: When two or more papers have similar authors, crowdsourcing projects, and results, we included the most detailed article.

3.1.5 Selecting papers

Papers were selected and organized using the Mendeley[1] tool. This platform was chosen because it's useful for organizing, annotating and filtering papers. After executing our query string on the selected digital libraries and removing duplicated papers, call for papers, and proceeding descriptions we started our study with the following numbers:

Table 2 – Papers related to crowdsourcing projects found in the digital libraries

Digital Library	Number of Papers
ACM Digital Library	378
Engineering Village	268
IEEE Xplore	249
Science Direct	50
Scopus	698
Total excluding intersections	947

Table 2 introduced the 947 papers that composed the first stage of reviews, which consisted of comparing the defined inclusion and exclusion criteria with the information obtained by reading the title, abstract, and keywords of these selected papers. This stage resulted in 813 excluded papers and 133 papers selected for the second stage of reviews, which applies inclusion and exclusion criteria on the full extension of the papers.

The second stage of our reviews resulted in 62 selected papers that presented 66 crowdsourcing projects for further analysis. It is noteworthy that some papers presented

[1] mendeley.com

multiple crowdsourcing projects, and in this situation, we considered the projects as multiple if they present different classifications.

Our searching and selecting papers process was repeated in May 2017 to update our review. After removing all papers found in our first search process, duplicates, and call for papers, our second search process found 153 new articles.

After applying inclusion and exclusion criteria in the title, abstract, and keywords, 31 of 153 new papers were selected for the second stage of reviews. In the second stage of reviews, we read and evaluated the 31 articles, and after this step, we selected ten papers that presented well-defined crowdsourcing projects to include in our study. We also published all references found in our query process in a Mendeley Dataset[2].

Unifying the two search process mentioned above, we gathered and evaluated data of 76 crowdsourcing projects found in 72 papers.

3.1.6 Data gathering

To gather relevant data about the selected papers, we classified the crowdsourcing projects using the four criteria mentioned in Section 3.1.2 plus the three following categories:

1. What is the purpose of the platform used in the project?(General-purpose or Specific-purpose)
2. What type of crowdsourcing task does the project apply? (Object processing, Object creation, Object evaluation, Object for solution)
3. What activities are responsible for managing quality during the crowdsourcing process?

3.2 Results

After gathering data from the 76 crowdsourcing projects by answering the questions addressed in the Section 3.1.6, This Section presents the tendencies and classifications evaluated in our review.

3.2.1 What is the crowd composition?

Our review found 50 crowdsourcing projects in which the crowdsourcer doesn't store information about the workers, classified as an anonymous crowd, and 26 projects in which the crowdsourcer stores individual information about the workers, classified as a specific crowd.

[2] http://dx.doi.org/10.17632/z5mrss39v7.1

Regarding the crowdsourcing projects that approached an anonymous crowd, 74% used general-purpose platforms (e.g. Mturk and CrowdFlower). However, 73,07% of the projects that engaged a specific crowd used specific-purpose platforms.

It's noticeable that general-purpose platforms are likely used for managing an anonymous crowd. General-purpose platforms typically manage several crowdsourcing projects, distributing tasks to anonymous workers and collecting results. If a crowdsourcer wishes to store information about the workers, it's possible to control a crowd by developing a specific platform that supplies his project needs, defining then a specific-purpose platform.

Table 3 – Tendencies in projects featuring anonymous and specific crowds

Crowd Members	Object Processing	Object Production	Object Evaluation	Object for Solution	Total
Anonymous	41 (82%)	2 (4%)	6 (12%)	1 (2%)	50 (100%)
Specific	18 (69,23%)	5 (19,23%)	2 (7,69%)	1 (3,85%)	26 (100%)

Table 3 indicates that most of the crowdsourcing projects that manage an anonymous crowd seek to perform object processing (e.g. image recognition, video annotation, text transcription). Therefore, the lack of information about the workers, that defines the pseudo-anonymity of the crowd (CHOWDHURY et al., 2014; CHANDLER; KAPELNER, 2013; KIM et al., 2011), limits the execution of complex tasks by anonymous workers. Lack of information about the crowd hinders crowd management, quality management, and evidence demographic limitations (KIM et al., 2011).

Regarding the projects that used specific crowds, even if 69,23% of the cases seek to perform object processing, studies similar to Feng et al. (2016) become possible to be executed. Their study presents the development of an educational game that aims to provide knowledge to students while they analyze biomedical images. Specific crowds also allow projects to be performed in laboratories, university campus, and specific geographic locations, as presented in the following papers: (GUPTA et al., 2012; KERMANIDIS; MARAGOUDAKIS; VOSINAKIS, 2015; TUITE et al., 2011; FIGUEROLA SALAS et al., 2013; LASECKI et al., 2012).

Storing information about workers allows the management of a crowd composed of specialists in specific knowledge fields, as approached in the studies of (DUMITRACHE et al., 2013; CHOWDHURY et al., 2014; MCALLISTER BYUN; HALPIN; SZEREDI, 2015; DWARAKANATH et al., 2015; HUYNH et al., 2014; FONCUBIERTA RODRÍGUEZ; MÜLLER, 2012). It's also possible to assemble users from platforms that aren't specifically developed for crowdsourcing means, such as the Facebook[3] and Adobe Photoshop[4],

[3] facebook.com
[4] adobe.com/photoshop

presented in the following studies: (SABOU; SCHARL; FÖLS, 2013; BANKS; RAFTER; SMYTH, 2015; DONTCHEVA et al., 2014).

3.2.2 What are the incentives offered?

Hosseini et al. (2015) enforced that crowdsourcing incentives can be intrinsic or extrinsic. Intrinsic motivations are a feature within the crowd, while the extrinsic ones come from the crowdsourcer, in the form of financial incentives or other forms. They also identified five types of intrinsic incentives: (i) Knowledge sharing; (ii) Love of community; (iii) Personal skills development; (iv) Self-esteem; and (v) Volunteering. During our classification, we summarized the incentives found within categories that we found relevant to calculate our tendencies.

Extrinsic incentives were present in 51 of 76 reviewed projects, while 21 projects used intrinsic incentives and four projects approached multiples motivations, that incentivized workers intrinsically and extrinsically.

Table 4 – Incidence of extrinsic incentives

Incentive	Incidence
Access	02 (03,64%)
Monetary	51 (92,73%)
Others	02 (03,64%)
Total	55 (100,00%)

Considering the information shown in Table 4, it's noticeable the predominance of monetary incentives, such as payments for each task done, raffles, and rewards to the best contributors. These incentives, mainly used in commercial platforms such as the Mturk, have the advantage of attracting large amounts of people to compose a crowd (CAO; CHEN; JAGADISH, 2014; KIM et al., 2011; KIM et al., 2014). Nevertheless, monetary incentives can be harmful to a crowdsourcing project, attracting malicious workers that only seeks to obtain financial rewards without caring about the work done (CAO; CHEN; JAGADISH, 2014; KIM et al., 2014).

Access incentives were present in papers which use the CAPTCHA approach (VON AHN, 2005). This method aims to prevent automatic access to websites by giving tests that only humans can solve. Using access as crowdsourcing incentive means that the workers will need to solve a task in exchange to access specific sites. By solving these tasks, the workers are contributing to a crowdsourcing project, as presented in the studies of Law &

von Ahn (2011), Hillen & Höfle (2015), Kim et al. (2014).

Another extrinsic incentive was presented in the work of (FENG et al., 2016), which motivated workers by providing school supplies to the students that participated in their crowdsourcing experiment.

Table 5 – Incidence of intrinsic incentives

Incentive	Incidence
Altruism	05 (20%)
Entertainment	15 (60%)
Learning	02 (08%)
Social	03 (12%)
Total	25 (100%)

Table 5 shows that 60% of the projects that use intrinsic incentives approached entertainment as motivation for the crowd. This incentive is defined by the term GWAP attributed by von Ahn & Dabbish (2008), which addresses games developed with the purpose of collecting human intelligence through tasks that entertain the player (VON AHN; DABBISH, 2008; TUITE et al., 2011).

Social incentives were exemplified in the study of Vukovic, Salapura & Rajagopal (2013), which publicly acknowledged the work done in the crowdsourcing tasks. Considering that the workers in this project belong to the same type of business, acquiring acknowledgment in this group is a viable incentive to execute tasks.

Projects that used altruism as incentive seek to mobilize people to benefit someone else. Studies found include natural disasters, as in the work of Hester, Shaw & Biewald (2010), which describes the effort to categorize and locate information received by SMS sent from people in an emergency during the earthquake that happened in Haiti, 2010. In this same natural disaster, the study of Zhai et al. (2012) seeks to identify damage done in buildings and structures. The work of Huynh et al. (2014) has the same purpose of the study of Zhai et al., but was executed during the earthquakes and tsunamis that happened in Japan, 2011.

Learning incentives were exemplified in the study of Dontcheva et al. (2014), which presented a crowdsourcing platform built inside the Adobe Photoshop platform. This crowdsourcing system offered advanced tutorials of image editing and provided training tasks to the workers, and then, the authors generated a database of edited images by combining the results of these tasks.

The studies of Feng et al. (2016) and Tuite et al. (2011) used the multiple incentives approach, by presenting entertainment incentives as the primary incentive and offering extrinsic incentives, such as school supplies, and financial incentives respectively, to the best contributors.

3.2.3 How the tasks are performed?

Observing the crowdsourcing projects reviewed, 71 of them used the defined task model, four cases approached the free contribution model, and one focused on the competition method.

Table 6 – Tendencies of the defined tasks category

Defined Tasks	Incidence
Audio processing	06 (08%)
Image processing	32 (45%)
Text processing	08 (11%)
Video processing	09 (13%)
Others	16 (23%)
total	71 (100%)

Table 6 presents processing tasks as the leading trend. This approach consists of tasks that request the workers to evaluate an object and process something, like annotations and markings. Object processing includes combining an object provided by the crowdsourcer with task results produced by workers, thus generating new objects or metadata to complement given objects. This approach was detailed in Section 3.1.2.

Image processing is exemplified in studies that produced annotations (FONCUBIERTA RODRÍGUEZ; MÜLLER, 2012; REDI et al., 2013) or markings (DELLA MEA et al., 2014; ESTES et al., 2016). The image marking approach differs from annotating images because the markings are attached to the visual content of an image, in other hand, annotations are independent because they use information contained in the image to generate additional content, such as metadata and text transcription.

Regarding video processing, the work of Nguyen-Dinh et al. (2013), and Sulser, Giangreco & Schuldt (2014) approached video annotation according to events that occurred in the video. The crowdsourcing project presented in Masiar & Simko (2015) seeks to collect video metadata by asking the crowd to search and compare the search results. In Di Salvo, Spampinato & Giordano (2016) workers segmented videos by playing a game about marine species. Figuerola Salas et al. (2013) used human intelligence to compare the quality between a pair of videos.

As for text processing, it's noticeable in the studies of Zhai et al. (2013) and Dumitrache et al. (2013) the usefulness of crowdsourcing to recognize medical text and combine them to produce reliable databases. The work of Mellebeek et al. (2010) appeals to the crowd for evaluating opinions about car brands, aiming the training of an opinion mining system.

Evaluating tasks that produce audio processing, the work of Lasecki et al. (2012) presents an approach for transcribing and subtitling audios on demand. The study of McAllister Byun, Halpin & Szeredi (2015) proposed to evaluate speeches using crowdsourcing, McNaney et al. (2016) described a mobile app for people with Parkinson's condition to manage their speaking capability by receiving feedback generated by a crowdsourcing project.

Crowdsourcing is a versatile approach when considering tasks and their results, therefore, a considerable number of reviewed projects differ from the classifications presented above, representing then the others category with 23% of the sampling exposed on Table 6.

Among the others category, three projects used crowdsourcing to verify and test software. Weidema et al. (2016) formulated tasks that aim to collect alternative design solutions to solve user interface problems, while Pastore, Mariani & Fraser (2013) proposed to evaluate the source code and behavior of programs, then aiming to find bugs in the software.

The project presented by To et al. (2016) provided an approach that asks the workers to visit selected landmarks, in a defined geographic region, and register how the landmark influenced in their mood. This project generated a map with landmarks and the feeling related to each mark.

Vukovic, Salapura & Rajagopal (2013) developed a project that used the intelligence of a specific crowd to compose technical documents. The work of Banks, Rafter & Smyth (2015) presented a game developed and published in the Facebook platform, which allowed the users to recommend movies to their friends, so the project could collect recommendation data afterward.

Free contribution tasks allow the crowd to use their creativity during the crowdsourcing process. The studies of Tuite et al. (2011) and Bayas et al. (2016) allowed the workers to take and send pictures related to a defined location, using their personal creativity and quality concepts.

Lasecki et al. (2013) requested that workers answer questions in a chat system with their own words. All workers in this project can vote in a response, and the answer with most votes was shown to the user that asked the question.

In competitive tasks, the workers compete by solving and submitting tasks to the crowdsourcer, who selects and reward the solution that best solves the proposed problem, as approached in the software development website TopCoder[5]. Dwarakanath et al. (2015) presented a methodology that managed a software development lifecycle, outsourcing the code implementation part produced with competitive tasks. The competitive tasks approach is useful to find specialists capable of producing reliable and complex results. However, skilled workers which participate in competitive crowdsourcing platforms frequently seeks better monetary rewards than those offered by microtask platforms. Dontcheva et al. (2014).

The second dimension presented in the work of Geiger et al. (2011) can be an interesting way to classify how crowdsourcing tasks are performed. This dimension, called accessibility of peer contributions, indicates if workers can access each other's contributions. The four characteristics of this dimension are: (i) None, which means that workers cannot see each other's contributions; (ii) View, in which all contributions are visible to any potential worker participating in the project; (iii) Assess, in which workers can vote, rate, and comment on other contributions; lastly, the (iv) Modify characteristic, which allows workers to modify and even delete each other's contributions.

3.2.4 What product is generated at the end of the project?

Table 7 shows the classification of products generated by crowdsourcing projects. The crowdsourcing approach is considerably used to produce media databases and these databases usually are applied to support systems and train artificial intelligence, as presented in (MAIER-HEIN et al., 2014; ALTMEYER; LESSEL; KRÜGER, 2016).

The software review approach is exemplified in the works of Dietl et al. (2012) and Fava et al. (2016), which proposed to verify systems by using crowd intelligence in GWAPs.

The study of Lasecki et al. (2013) presented a chat system powered by crowdsourcing. The workers in this project are monetarily rewarded by voting on the best answers or by producing the selected answers.

Tuite et al. (2011) developed a competitive game that motivated University of Washington students to take pictures of specific buildings in the university. As a result of this project, they generated 3D building models from the pictures taken by the workers. The results of this project are available at the Photo City website[6].

[5] [topcoder.com]
[6] photocitygame.com

Table 7 – Products generated by crowdsourcing projects

Product	Incidence
Processed Audio	06 (08%)
Processed Images	34 (45%)
Processed Text	07 (09%)
Processed Videos	09 (12%)
Software Review	06 (08%)
Others	14 (18%)
Total	76 (100%)

3.2.5 What is the purpose of the platform used in the project?

Our review is focused on understanding how crowdsourcing projects are designed and implemented nowadays, therefore, it is important for us to evaluate general-purpose platforms and their limitations. By reviewing crowdsourcing projects, we perceived the positive and negative sides of these platforms, due to papers that developed specific-purpose platforms to execute crowdsourcing projects, which frequently described the limitations in general-purpose platforms that led them to develop a specific platform.

Table 8 – Usage of general and specific-purpose crowdsourcing platforms

General-purpose platforms	Incidence
Amazon Mechanical Turk	24 (32%)
CrowdFlower	11 (14%)
Others	09 (12%)
Total General-purpose	44 (58%)
Total Specific-purpose	32 (42%)
Total	76 (100%)

Among the 76 reviewed crowdsourcing projects, 44 of these used general-purpose platforms to manage their project. Table 8 presents that the Mturk platform shows greater popularity between these platforms. This platform is capable of managing the development, execution, and validation of crowdsourcing tasks quickly and at low cost, due to numerous subscribed workers available to solve tasks (MCALLISTER BYUN; HALPIN; SZEREDI, 2015; ALONSO; MIZZARO, 2012; YANG et al., 2010).

The Mturk platform allows the crowdsourcer to manage crowd workers, enabling them to limit worker participation based on previous work done, acceptance rate of tasks, based on geographic location of the workers, and also by designing qualification tests that the workers should pass to be able to work on a specific project (ALONSO; MIZZARO, 2012; MCALLISTER BYUN; HALPIN; SZEREDI, 2015; CHANDLER; KAPELNER, 2013; YANG et al., 2010; CAN; ODOBEZ; GATICA-PEREZ, 2014). However, our review pointed out the following limitations when managing a crowd on this platform: (i) Lack of information and control about the workers (CHOWDHURY et al., 2014; CHANDLER; KAPELNER, 2013; KIM et al., 2011); (ii) crowd participation is geographically limited (ROSS et al., 2010; CHOWDHURY et al., 2014; DELLA MEA et al., 2014); (iii) worker's incentive is inflexible (CAO; CHEN; JAGADISH, 2014; KIM et al., 2014).

Another limitation found on the Mturk platform is the difficulty in assembling some tasks within their standard templates, forcing crowdsourcers to host their application in a separate server and post a link in the tasks (MCALLISTER BYUN; HALPIN; SZEREDI, 2015; KIM et al., 2011). Mturk is also limited in the qualification tests and validation mechanisms provided (ASHIKAWA; KAWAMURA; OHSUGA, 2015; KIM et al., 2011; ALONSO; MIZZARO, 2012).

The CrowdFlower platform differs from Mturk in two primary points, the first is a possibility to use a specific markup language alongside with HTML, CSS, and Javascript to develop tasks in this platform (DELLA MEA et al., 2014; FONCUBIERTA RODRÍGUEZ; MÜLLER, 2012). The second point is being able to aggregate diverse crowdsourcing platforms as task channels, including Mturk, thus allowing the crowdsourcer to select various channels that his task will be published (FONCUBIERTA RODRÍGUEZ; MÜLLER, 2012; FIGUEROLA SALAS et al., 2013).

Unexpectedly, the Facebook social network was used as a general-purpose platform. This platform provides an API (Application Programming Interface) for the development of games and applications, besides providing information about potential workers and their social relationships. Hence, allowing crowdsourcers to manage a crowdsourcing project on this platform, using entertainment as intrinsic incentive (SABOU; SCHARL; FÖLS, 2013; BANKS; RAFTER; SMYTH, 2015). It's noteworthy that the Facebook platform also can be used to collect crowdsourcing votes through its comment system.

Another general-purpose platform found is the Freelancer platform, which enables the competitive crowdsourcing approach (DWARAKANATH et al., 2015). The platform developed by Brambilla et al. (2014) offers the possibility to modify the execution of a crowdsourcing project by changing between anonymous and specific crowd during the process.

Microworkers (SULSER; GIANGRECO; SCHULDT, 2014; REDI et al., 2013), C-SATS (VERNEZ et al., 2017), Crowdtesting (LEICHT et al., 2016), and oDesk (LEANO; WANG; SARMA, 2016) are other general-purpose platforms used in the reviewed projects.

Platforms developed specifically to manage specific experiments were considered as specific-purpose platforms, presented in 32 of the 76 cases.

Specific-purpose platforms were eventually developed to supply some limitations of general-purpose platforms, as presented in the studies of Brambilla et al. (2014) and Castano et al. (2016), which developed platforms that allowed flexible crowd management. Another important point is that 62,5% of projects that used specific platforms motivated workers by applying intrinsic incentives, while only 11,36% of projects in general-purpose platforms used them as motivation.

Considering projects in which the crowdsourcer stored information about his crowd of workers, 59,37% of projects in specific platform managed a specific crowd, while only 15,90% of projects in general-purpose platforms approached this type of crowd.

Table 9 – The incidence of task types in crowdsourcing platform types

Platform Type	Object Processing	Object Production	Object Evaluation	Object for Solution	Total
General	36 (82%)	0 (0%)	6 (14%)	2 (5%)	44 (100%)
Specific	23 (72%)	7 (22%)	2 (6%)	0 (0%)	32 (100%)

Table 9 shows that crowdsourcing is mainly used to process objects. This table also informs that general-purpose platforms tend to execute object evaluation and problem-solving approaches, while object production tasks were only performed in specific-purpose platforms.

Some of the reviewed projects presented the development of a crowdsourcing platform that seeks manage tasks and supply limitations of general-purpose platforms, but still uses these systems to select and control the crowd due to the easiness in engaging workers. General-purpose platforms allow the crowdsourcer to design the called external HITs, which consists of tasks hosted on another platform, that are provided to the workers through links and access codes, as presented in McAllister Byun, Halpin & Szeredi (2015), and Nguyen-Dinh et al. (2013).

3.2.6 Quality management in crowdsourcing

Crowdsourcing projects frequently face difficulties to guarantee reliable results to the crowdsourcer (KIM et al., 2011), including cases that provide monetary rewards to the workers (CAO; CHEN; JAGADISH, 2014; ALTMEYER; LESSEL; KRÜGER, 2016).

Therefore, the use of quality control mechanisms is essential to guarantee quality in the crowdsourcing project and avoid wasting resources.

During our systematic review, only 10 of 76 crowdsourcing projects didn't specify how the quality was managed in their crowdsourcing process. By analyzing the quality management of the 66 remaining studies, we observed the following tendencies: (i) Activities that occur before the crowdsourcing process (Pre-task); (ii) techniques applied during the task execution (During-task); (iii) mechanisms used after the task execution (Post-task).

Table 10 – Incidence of pre-task mechanisms

Pre-Task Mechanisms	Incidence
Pre-Processing	11
Qualification Tests	12
Training	15
Worker Accuracy	08
Total Incidence	34

Table 10 presents the activities applied in the pre-task stage, present in 34 of 76 projects. These activities are responsible for training workers, filtering workers, simplifying task execution, and preprocessing objects used to generate tasks. However, these methods don't grant the quality of a product generated by crowdsourcing, because these activities occur before task execution and it's impossible to predict how the workers will produce the results. Therefore, these techniques help to avoid malicious workers and poorly done work (TAVARES; MOURÃO; MAGALHAES, 2013; CHOWDHURY et al., 2014; ALONSO; MIZZARO, 2012; NGUYEN-DINH et al., 2013).

Another way to qualify workers is to insert a mandatory training stage before task execution. This stage usually consists of a set of instructions that aims to train workers to properly execute the crowdsourcing tasks in a project, as presented in (LASECKI et al., 2013; HUYNH et al., 2014; DONTCHEVA et al., 2014; FENG et al., 2016).

The qualification tests approach means to insert a mandatory test that a worker must pass in order to work on a project. The result of this test defines the ability of the workers to solve the proposed tasks, as approached in (ESTES et al., 2016; IRSHAD et al., 2015; WEIDEMA et al., 2016).

Pre-processing consists of using algorithms and procedures in the objects provided by the crowdsourcer, aiming to design tasks that can be easily solved. The work of Dumitrache et al. (2013) preprocesses the objects to add metadata and generate automatic annotations, thus simplifying the tasks provided to the crowd. Soleymani (2015) preprocessed an image database, removing content that is irrelevant.

Worker accuracy is a technique used mainly in general-purpose platforms because these platforms store execution data of their workers. Considering the acceptance of work previously done and accounting for a percentage of approval, this mechanism limits the participation in a project by requiring that the workers should have an acceptance rate equal or higher than a percentage defined by the crowdsourcer to participate in a project (YANG et al., 2010; ASHIKAWA; KAWAMURA; OHSUGA, 2015; CAN; ODOBEZ; GATICA-PEREZ, 2014).

During-task quality management was used in 21 of 76 projects, and 52% of these projects presented a method called task design, which consists of rules applied during the tasks execution stage, aiming to exclude task results that diverge from defined standards. Della Mea et al. (2014) defined that the workers should recognize a minimum number of cells in each image to be considered as a valid task. The work of Zhai et al. (2012) verified the amount of time that a worker spent on a task and compares this time with the average time spent by other workers, thus defining that if the worker is executing the task with proper care, his time spent in each task should be near the average time.

The gold standard mechanism was used in 62% of the projects that approached during-task quality management, and this technique merges ground truth questions with crowdsourcing tasks. Workers that gives the wrong answers to the ground truth questions were considered unable to respond to a crowdsourcing task correctly, and their results are discarded. This technique was used in the following studies (ZHAI et al., 2013; TAVARES; MOURÃO; MAGALHAES, 2013; HILLEN; HÖFLE, 2015).

Table 11 – Incidence of post-task mechanisms

Post-Task Mechanisms	Incidence
Majority Decision	41
Post-Processing	11
Review	12
Subtasks	06
Total Incidence	57

Table 11 presents the post-task quality mechanisms, used in 57 of 76 projects. These methods are capable of aggregating multiple task results and generate a reliable result and also filter undesirable task results after the task execution.

The majority decision, or majority voting, is the most used activity for quality management and was present in 41 crowdsourcing projects. This technique is frequently used in the microtask approach and consist in the replication of one task in a defined number of identic tasks. After the replicated tasks are solved, the results are aggregated, and the crowd consensus is considered as the task results. This approach was presented in the studies of (SABOU; SCHARL; FÖLS, 2013; LONI et al., 2014; IRSHAD et al., 2015; LASECKI et al., 2012; TUITE et al., 2011).

The review method consists of manually reviewing the work done by the workers, thus the project manages will decide the acceptance of the work. This activity was approached in (LASECKI et al., 2012; DONTCHEVA et al., 2014; DUMITRACHE et al., 2013).

The Post-processing technique consists of optimizing the results obtained after the task execution stage, usually with computational aid. The studies of Hillen & Höfle (2015) and Taborsky et al. (2015) used post-processing to combine the image markups provided by the crowd. Tuite et al. (2011) unified images sent by the workers to generate 3D models of buildings.

The subtasks mechanism is useful to evaluate work done by a crowd. This technique consists of generating new crowdsourcing tasks and requesting workers to verify objects produced by a crowdsourcing project, as presented in (ROEMMELE; ARCHER-MCCLELLAN; GORDON, 2014; RAMCHURN et al., 2013).

3.3 Brief conclusion and limitations

In this Chapter, we exposed the methods and results of our systematic literature review of crowdsourcing projects. During this review, we gathered important knowledge about the crowdsourcing state-of-the-art and perceived neglected concepts, which were applied during the development of a crowdsourcing conceptual model, presented in the following Chapter.

As limitations, our review approached indexed papers of the literature, thus, some important material that could contain valid crowdsourcing projects was not included in this review, such as dissertations, white papers, short papers, and papers that we did not have access. Also, crowdsourcing projects with commercial purposes can have different configurations from crowdsourcing projects with academic purposes, hence, limiting our point-of-view.

After perceiving that a crowdsourcing project can have a workflow that executes multiple sets of tasks, we addressed an issue present in our review. Quality management activities, named subtasks, presented in Section 3.2.6, manage the quality of a previous task results. However, after perceiving that a crowdsourcing workflow can have multiple task sets, we decided that the subtasks are better represented as a crowdsourcing task of object evaluation type.

Table 12 – The three types of crowdsourcing tasks

Type	Production Method	Suitable for
Object Processing	The crowdsourcer gives X objects and a task description to a Y number of workers, the outcome can be Z modified objects or the initial objects together with N new annotation data.	e.g., Content analysis (Object recognition, Text annotation, Image annotation, Image and Video segmentation), Translation.
Object Evaluation	The crowdsourcer gives X objects, and Y workers evaluate these objects, the outcome can be a set of ratings, rankings, or evaluation metadata.	e.g., Quality evaluation, Voting.
Object Production	The crowdsourcer gives a task description, and the workers produce X objects according to the description. In some cases, the outcome can be the best suitable solution for a proposed problem.	Data production (e.g., Multimedia content, Design content, Software developing.)

As another issue, we perceived that the Object Production and Object for Solution task types, presented in Section 3.1.2, can be aggregated as one task type. We observed that these two types of tasks are executed in the same way, and the differences that we previously defined are related to the concepts of incentive and quality management, hence, the concepts related to the task itself are identical. Therefore, Table 12 summarizes the three types of crowdsourcing tasks, according to our new classification scheme.

4 Modeling Crowdsourcing Projects

After concluding the systematic literature review presented in Chapter 3, we perceived that the crowdsourcing projects reviewed usually did not follow any guidelines or models to present how they are planned and executed. Therefore, we defined a reference conceptual model, based on the empirical knowledge acquired during the aforementioned review, which provides an organized structure for the development/design of crowdsourcing projects.

By researching in the state-of-the-art of crowdsourcing, we perceived that there is not a reference conceptual model, framework, or even modeling principles systematic applied to establish a shared view on the main entities and relationships involved in Crowdsourcing projects (LUKYANENKO; PARSONS, 2013).

The analysis of gathered data revealed that even with all the challenges of creating a conceptual model for the crowdsourcing domain (LUKYANENKO; PARSONS, 2012), it is possible to design a structural conceptual model to be used as a reference model for guiding Crowdsourcing projects. Also, we concluded that such conceptual model should specify nine fundamental entities and their relationships, as shown in Table 13.

Table 13 – Crowdsourcing essential elements and their primary functions

Element	Functions
Crowdsourcer	Design and sponsor the project.
Crowdsourcing Platform	Manage workers and tasks.
Workers	Solve tasks in exchange for a specific reward.
Tasks	Activities executed by the workers in order to generate desired results.
Recompense Mechanisms	Incentives proposed to the workers to perform a task.
Control Activities	Manage the quality of the product generated and avoid waste of resources.
Project Workflow	Manage the execution of tasks, control activities, and incentive applications to generate reliable results.
Assets	Objects to be processed and tools required to perform the tasks.
Product	Main result generated at the end of the project workflow by compiling task results.

4.1 A General Crowdsourcing Structural Conceptual Model

Looking at Crowdsourcing projects, we can perceive two main phases involved: planning the project, and executing it. Thus, we decided to specify our structural conceptual model using three diagrams. The first one addresses the planning stage of a crowdsourcing project, the second one represents the execution stage of a project, and the third one represents the interaction between these two diagrams by relating their elements.

4.1.1 Planning Crowdsourcing Projects

Figure 2 shows the class diagram representing the fundamental elements related to the planning stage of a crowdsourcing project. Every project starts with a crowdsourcer, that can be an individual or an organization, sponsoring and planning the project. First, the crowdsourcer must define the project workflow, defining the types of tasks (e.g., image processing task) and control activities (e.g., filter worker participation, aggregate results by majority decision) to be performed in the project.

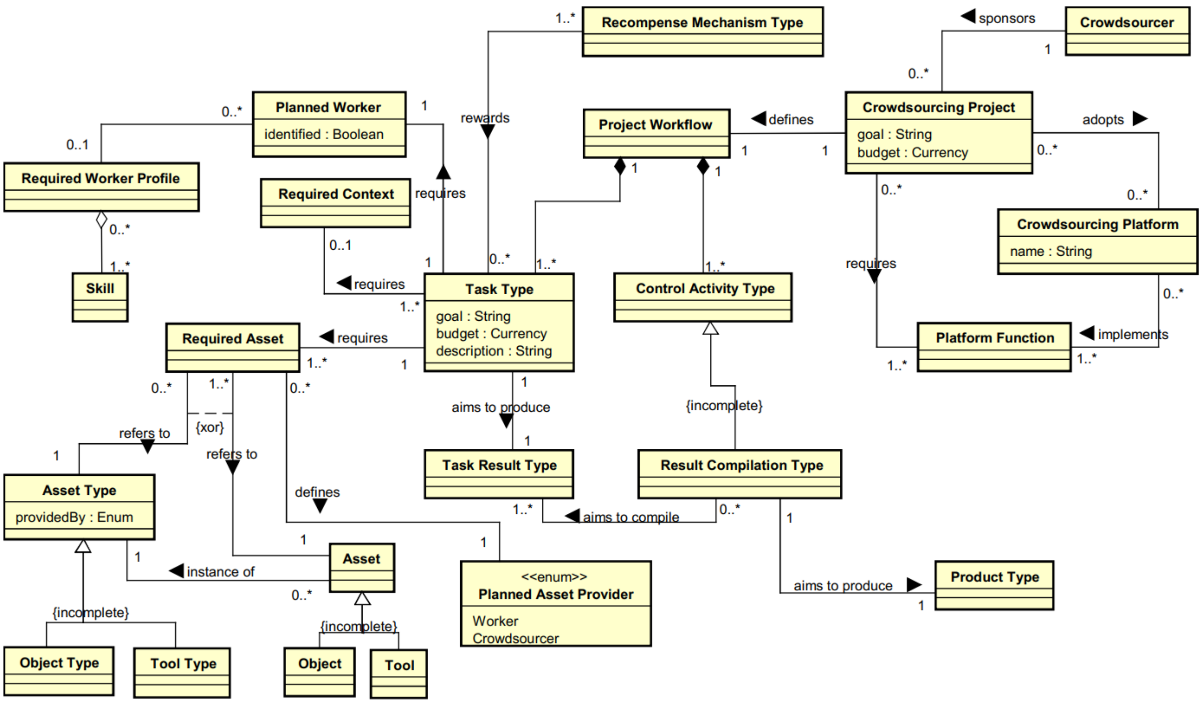


Figure 2 – Class diagram representing the planning stage of crowdsourcing projects.

Each task type must have a goal (i.e., what this type of task aims to produced) and a description (i.e., what will be informed to the workers, specific details, etc.), and must indicate whether its workers are identified or anonymous and if a worker profile is required. This profile is a set of skills required to solve this type of task. Moreover, the crowdsourcer can set a monetary value as a budget to be used in this task type.

Task types also require assets, that can refer to a type of asset ()e.g., images as an object type, image editing software as a tool type), or may refer to specific assets, such as one specific and identified video that will be segmented in the related task type (object) or a specific image editing software like the Adobe Photoshop (tool). A required asset can be provided by the crowdsourcer or by the workers.

Other important concern that the crowdsourcer should pay attention during the planning stage of the project is if the defined task types require a context to be executed properly. According to Vieira, Tedesco & Salgado (2005) a context can be defined as any information used to characterize the situation of an individual, in this case, a worker, during the project. Therefore, a required context represents the ideal scenario that a worker should fit during the execution of a task of such type in the project.

An example of how worker's context can influence a crowdsourcing project can be seen in the work of Gupta et al. (GUPTA et al., 2012). This study was executed in a semi-urban area near Bangalore, India, in which the authors aimed to recruit workers that did not have easy access to computers, smartphones, and the Internet. Thus, the authors took into consideration that workers living in a semi-urban area, without having access to advanced technology, would only have some basic knowledge of the English language. Therefore, by understanding the relation of the proposed tasks and the context that the workers who will solve them must belong, the crowdsourcer knows that he needs to describe the tasks with clear and basic English instructions. Considering this same context, a more complex task could need translation to the local language (Kannada) in order for the workers to understand it.

Given that the context element is not mandatory in a crowdsourcing project and context-sensitive applications infer a different field of study, and also to keep this general model friendly to newcomers, we designed it as a black box and alerted its relevance. Detailed information about context-sensitive applications can be found in the work of Vieira, Tedesco & Salgado (2011).

Every crowdsourcing project needs to identify some functions that will be essential to manage the execution of the project. These functions are implemented by platforms. A crowdsourcing platform can implement one or more of these functions (i.e., one platform manages workers and forward these workers to other platform to distribute tasks for them). Moreover, during the planning stage of the project, the crowdsourcer can define the required platform functions that should be implemented, postponing the choice of the platform to be used to the execution stage, or he can already specify the platforms (i.e., plan a project already stating that will use the Mturk platform) during the planning stage of the project.

We identified two essential platform functions: (i) Task Management and (ii) Worker Management. The task management function is responsible for distributing tasks to be accomplished by the crowd and collecting their results, while the worker management function should subscribe, filter, and forward workers to the task management function. These two features can be accomplished by one or more platforms.

Other elements that compose the project workflow are the types of control activities, that are essential to guarantee quality throughout the crowdsourcing project.

When the crowdsourcer plans a type of task, he already expects a type of result that will be produced. These types of results are planned to be compiled by at least one type of control activity (e.g., aggregate the results to segment images) to produce a product of the desired type (e.g., generate a new dataset of images segmented during the project), otherwise, the crowdsourcing project cannot ensure reliable results. Information about popular types of control activities used in crowdsourcing projects can be found in Section 3.2.6.

The crowdsourcer also must have in mind that the workers will want some type of reward to work in a project (e.g, monetary rewards, social incentives). Therefore, the recompense mechanism type represents the planned rewards that will be offered to the workers who execute a task. Section 3.2.2 shows the recompense mechanism types used in the literature.

It is noteworthy that the Project Workflow element representation in this diagram shows that it is composed of types of tasks and control activities. However, since a crowdsourcing workflow usually is unique in each individual project and it represents a flow of activities that should be executed to generate a product using crowdsourcing, a structural model cannot represent this execution flow. Therefore, we suggest that the crowdsourcer should model an individual project workflow using a behavioral conceptual model, which will be further described. Moreover, other models/approaches can be used to design this element, depending on the crowdsourcer's needs.

4.1.2 Executing Crowdsourcing Projects

Figure 3 represents the execution stage of a crowdsourcing project. During this stage, the project must engage workers that match with what was planned beforehand. These workers, who can be anonymous (e.g, $worker\ id = "x"$) by not providing any personal info to the crowdsourcer or identified as a person (e.g., $worker\ id = "x", worker\ name = "y", skills[] = "java\ knowledge", "javascript\ knowledge"$), will engage in a project through a platform that implements the worker management function, thus being able to perform tasks.

The tasks, instances of task types planned in the previous stage, occur in a context and can use assets provided by either the crowdsourcer or workers, depending on the task. As an example, in an object processing task, the crowdsourcer gives images as assets to the workers process them, while in an object production task, the crowdsourcer request

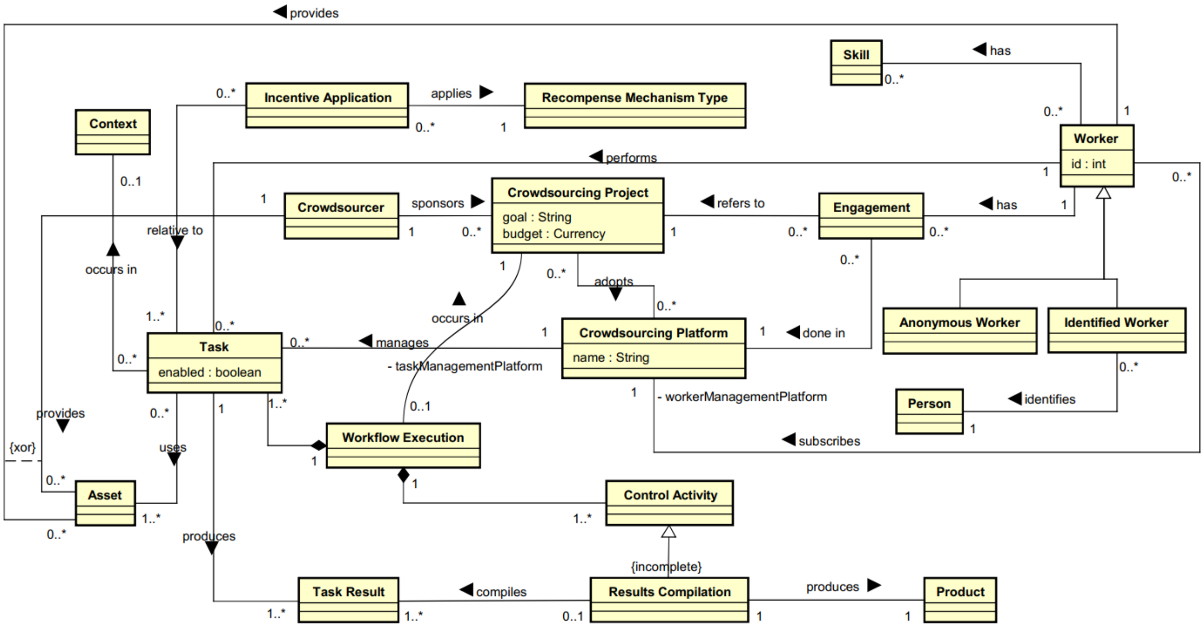


Figure 3 – Class diagram representing the execution stage of crowdsourcing projects.

that the workers submit pictures to create a dataset, thus the worker provides images as assets in this case. The execution of these tasks is managed by crowdsourcing platforms that implements the task management function.

The incentive application element is responsible for applying the types of recompense mechanisms planned in the previous stage. This application is related to a task and rewards the worker who performs the task, e.g, the $worker\ id = "x"$, who performed the $task\ id = "y"$, receives an incentive application that is bound to the $task\ id = "y"$.

The workflow execution element represents the execution of the workflow planned in the previous stage. It is composed of the aforementioned tasks and the control activities. Control activities are actions taken to manage the quality of some element of the project, e.g., filtering worker participation, excluding poorly executed tasks, and discarding divergent task results. The workflow of a crowdsourcing project must contain at least one task and one control activity.

The control activity responsible for generating a product is called the result compilation. To generate the desired product, this activity will compile the task results to compose the final product of the crowdsourcing project, according to the compilation planned beforehand (e.g., gather the images segmented by the workers and validated by an automatic algorithm, as another control activity, and aggregate it into a new image dataset).

4.1.3 Linking Crowdsourcing Project Planning and Execution

Figure 4 integrates the planning and execution stages of a crowdsourcing project, showing the relationships between these two stages and indicating the execution instances of the planned elements.

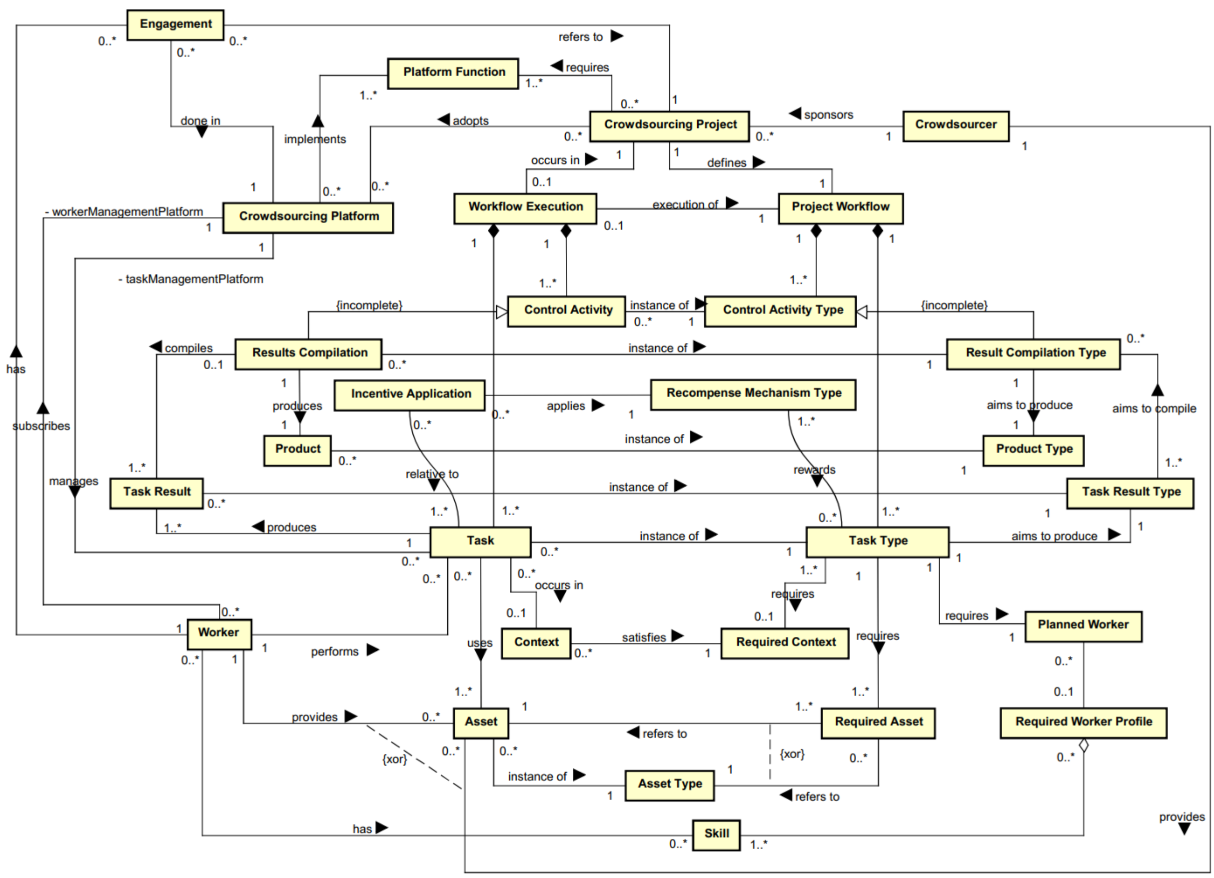


Figure 4 – Class diagram representing the overview of crowdsourcing projects.

It is noteworthy that some details about the elements presented in these diagrams were not approached, such as task execution time, worker reputation, control activity efficacy, among others. We decided not to approach these matters because they are not important for every project and more studies are needed to proper define and design them.

4.2 The use of behavioral conceptual models to represent the planning of project workflows

Behavioral schemes, such as activity diagrams, specify the valid changes in the domain state, as well as the actions that can be performed. Changes in the domain state are called domain events, which represent the changes that occur in the domain state over time (OLIVÉ, 2007).

Considering that the domain state of a crowdsourcing project will change according to the execution of its workflow, this execution cannot be well defined in a general-purpose class diagram. Therefore, we consent to Bozzon et al. (2014) and propose the use of behavioral schemes to model the planning of crowdsourcing workflows.

Tasks and control activities, which can be done in parallel, iterative, or sequential ways during the execution of a crowdsourcing workflow, represent the events that occur in the domain state of the projects, changing it. Therefore, to represent these events and their related information (e.g, agents and objects involved, control flow and so on), we suggest the use of activity diagrams to better design these elements of the execution of crowdsourcing projects.

It is noteworthy that the Project Workflow (Planned) and the Workflow Execution (Executed) elements are different. The Project Workflow should be designed using this kind of conceptual models to help the crowdsourcing to understand what he needs to set before executing it and how he should control the execution flow. The Workflow Execution then will be an instance of what was planned beforehand, given that, we believe that modeling the execution of a workflow is not necessary/beneficial for a project, since the project and the workflow execution usually finish at the same time.

To exemplify how the execution of a crowdsourcing workflow can be represented step-by-step by using an activity diagram, we selected two projects from the 76 reviewed in our systematic literature review, presented in Chapter 3, to represent the execution of their workflows using a behavioral schema. The first of these two projects accomplished image processing and applied a sequential workflow, while the second regards software development and applied a parallel workflow with an outsourcing branch.

Moreover, for each of the projects presented in the following sections, we show their information related to each of the essential elements of a crowdsourcing project defined in our general model.

4.2.1 Is That a Jaguar?

The crowdsourcing project presented by Can, Odobez & Gatica-Perez (2014) aimed to obtain image annotation and segmentation data at scale. Table 14 shows how its essential elements are described in terms of the entity types of our structural conceptual model. It is noteworthy that a required profile and skills were not necessary in this project, considering that its task did not require any previous skills from the workers which participated in the project.

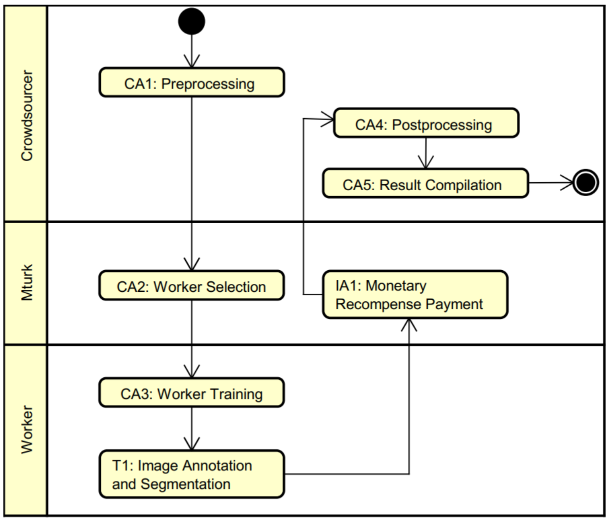
Table 14 – Crowdsourcing essential elements represented in the work of Can, Odobez & Gatica-Perez (2014)

Entity Types	Instances
Crowdsourcer	The authors of (CAN; ODOBEZ; GATICA-PEREZ, 2014).
Crowdsourcing Platform	The Mturk platform managed workers and tasks.
Workers	Anonymous, no specific skills or information required.
Tasks	Image annotation and segmentation.
Recompense Mechanisms	Monetary rewards.
Control Activities	Preprocessing; Worker Selection; Worker Training; Postprocessing; Results Compilation.
Project Workflow	The workflow managed one task and five control activities. This workflow is detailed in Figure 5. In their paper, the workflow was textually described, without following any standard.
Assets	Images to be processed and segmentation tool provided by the Crowdsourcer.
Product	Dataset of segmented and annotated images.

Figure 5 shows the workflow execution of the aforementioned project. In this project, the first control activity consisted of the crowdsourcer preprocessing images of ancient Maya glyphs, thus guaranteeing that good quality images will be provided to the workers to segment them.

As a second control activity, the Mturk platform selected workers with 95% or more accuracy in previous tasks to work in the task designed by the crowdsourcer. Then, the third step consisted of a training stage that showed an instructive video of how to correctly solve the following tasks.

The workers selected by the previous control activities became able to work in the



Caption: CA (Control Activity); T (Task); IA (Incentive Application).

Figure 5 – Proposed activity diagram to represent the workflow execution of Can, Odobez & Gatica-Perez (2014).

object processing task, that consisted of evaluating and segmenting Maya glyph images. The workers received a monetary recompense after solving the proposed task.

After collecting the task results, the crowdsourcer post-processed the segmentation produced by the workers and compiled the results for further analysis, thus ending their project workflow.

4.2.2 Crowd Build

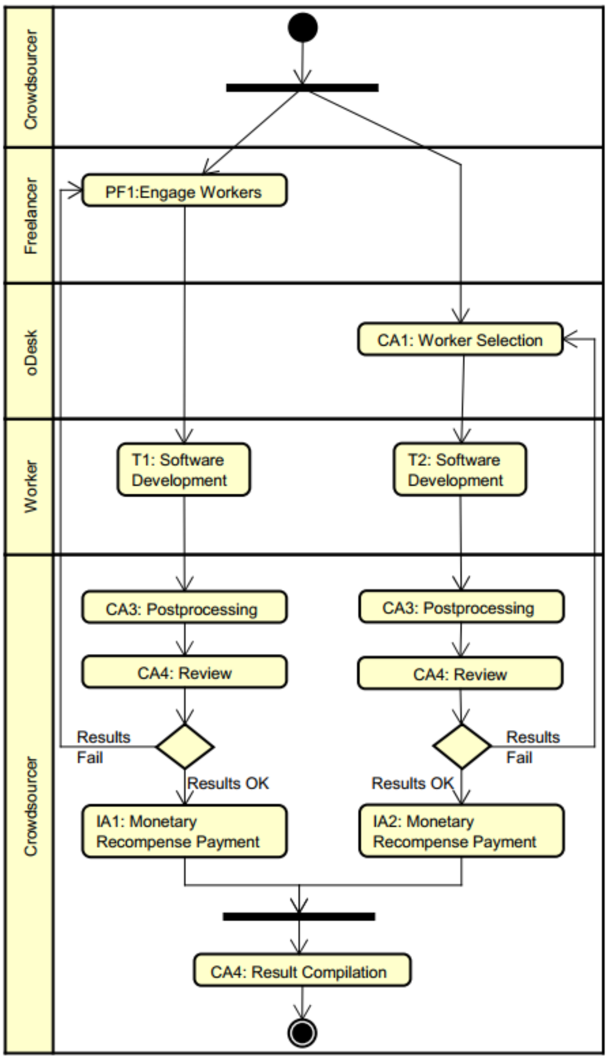
The crowdsourcing project presented in (DWARAKANATH et al., 2015) aimed to outsource the coding stage of the software development process to the crowd. Table 15 shows how its essential elements are described. Different from the previous workflows, the type of task applied in this project required a profile containing skills, such as: (i) Understand the typical web application architecture, composed of a front-end, a business logic layer, and a database; (ii) be capable of developing software using the Java programming language.

Table 15 – Crowdsourcing essential elements represented in the work of Dwarakanath et al. (2015)

Entity Types	Instances
Crowdsourcer	The authors of (DWARAKANATH et al., 2015).
Crowdsourcing Platform	The Freelancer and oDesk[1] platforms to manage workers and tasks.
Workers	Identified, workers with software development skills.
Tasks	Software Development.
Recompense Mechanisms	Monetary rewards.
Control Activities	Distribute Tasks to Workers, Suggest Workers, Worker Selection, Postprocessing, Review, and Results Compilation.
Project Workflow	The workflow managed the forementioned tasks and control activities in parallel. This workflow is detailed in Figure 6. In their paper, the workflow was described in an image that shows their entire software development methodology.
Assets	Software development tools provided by the workers.
Product	Developed and tested software.

Figure 6 shows the workflow execution of this project. We represent its activity diagram with two independent flows, a crowdsourcing flow, and an outsourcing flow. The first flow started with the crowdsourcer posting seven software development problems to be solved by competition in the Freelancer platform. In the second flow, the crowdsourcer selected developers suggested by the oDesk platform to work as outsourcers and generate software.

The Freelancer platform engaged workers by broadcasting the task description, then, each worker developed the code according to the task description. On the other hand, the oDesk platform suggested workers by matching the task description with their



Caption: PF (Platform Function); CA (Control Activity); T (Task); IA (Incentive Application).

Figure 6 – Proposed activity diagram to represent the workflow execution of Dwarakanath et al. (2015).

worker profile. Then, the crowdsourcer chose specific workers and forwarded tasks directly to them.

Each task outcome was post-processed by automated software tests, and the validated results were forwarded for manual review. In the freelancer platform, the worker whose provide the best suitable solution to the proposed problem received a monetary reward, while other workers didn't receive any payment. In the oDesk platform, previously selected workers received a monetary reward if their production satisfied the given problem. If the task results didn't satisfy the crowdsourcer needs, the process could start again in a previous stage defined by the crowdsourcer.

After collecting satisfactory task results, the result compilation activity generated the product of this crowdsourcing project.

The next section presents a crowdsourcing project that followed our conceptual model as guidelines to plan and execute the project. Moreover, this project also modeled the execution of its iterative workflow using an activity diagram, as we suggested above.

4.3 Model in Practice

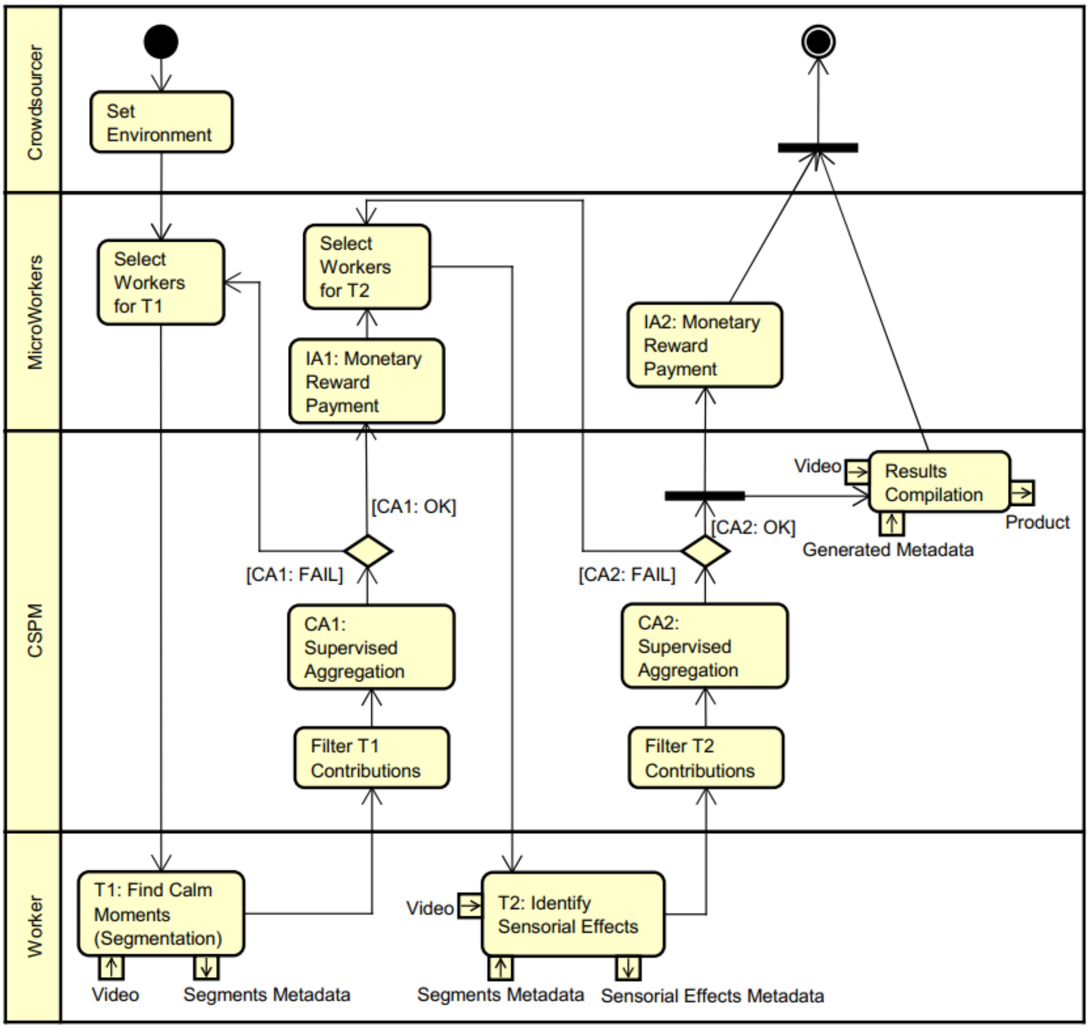
We've planned and executed a crowdsourcing project, alongside with other students of the Networks and Multimedia Research Laboratory (LPRM) at Federal University of Espírito Santo (UFES). This case study approached a project focused on achieving complex video annotations through an iterative and cascading crowdsourcing workflow. Despite not instantiating our structural conceptual model to generate a specific diagram for this project, our conceptual model served as guidelines to plan and execute this case study.

Table 16 – Crowdsourcing essential elements of Amorim et al. (2018)

Entity Types	Instances
Crowdsourcer	The authors of (AMORIM et al., 2018)
Crowdsourcing Platform	The MicroWorkers platform to manage workers and a specific crowdsourcing platform to manage tasks.
Workers	Anonymous.
Tasks	Video annotation and segmentation tasks.
Recompense Mechanisms	Monetary rewards.
Control Activities	Supervised Aggregation.
Project Workflow	This workflow manages two cascading crowdsourcing tasks, in which each task and aggregation outcome became the income of a new set of task and aggregation, until the results compilation to end the project.
Assets	A video object to be processed and annotation tools provided by the crowdsourcer.
Product	Video enriched with annotations.

The first contribution of our model during the planning stage of this case study was to understand which are the essential elements of a crowdsourcing project, as shown in Table 16. It is important to notice that the two crowdsourcing platforms were already defined since the planning stage of the project. Also, the unskilled workers would need some types of tools to be able to execute the proposed types of tasks in a proper way, which led the crowdsourcer to provide the annotation tools used during the execution of the project.

Moreover, our model guided us to set all the constraints related to our task and control activities instances, to configure incentive applications to apply the monetary recompense mechanism planned, and to have an overview of the execution of this project. Therefore, our execution conceptual model helped the crowdsourcer of this project to understand the roles of each essential element, thus facilitating the design of the project workflow of this case study, shown in Figure 7.



CSPM (Crowdsourcing Project Management); T (Task); CA (Control Activity); IA (Incentive Application).

Figure 7 – Activity diagram of the crowdsourcing workflow execution of (AMORIM et al., 2018).

The workflow starts with the MicroWorkers platform selecting and forwarding workers to participate in the first task, which consists of watching a video on a platform developed by the authors and finding moments without any wind and vibration sensation in the video. After receiving the task results, they were aggregated by a Supervised Majority Decision, which is the automatic aggregation of the results with the crowdsourcing supervising the convergence of results and controlling the iterations, forwarding the silent points that have sufficient contributions and iterating the ones that didn't converge until they reach a satisfactory result. After converging all the results, the MicroWorkers platform applies the monetary incentive to the workers.

The income of the second task is the video segments produced according to the silent points generated by the first stage of the workflow, then, after selecting new workers, the second task consists of the workers identifying vibration and wind effects in the video segments. The aggregation of these tasks is identical to the previous one.

After the second aggregation, the MicroWorkers platform rewards the participants while the CSPM platform compiles the results to produce a video enriched with the metadata produced throughout the process, thus ending this workflow.

4.4 Model Discussion

To validate our assumptions, Table 17 compares the nine essential elements of crowdsourcing with the integrated definition of the crowdsourcing term presented in Estellés-Arolas & Guevara (2012). Their definition worth comparison because it integrates a considerable number of crowdsourcing definitions, including well-cited papers of renowned authors in this field of study, such as Howe (2008), Brabham (2008), and Doan, Ramakrishnan & Halevy (2011).

Table 17 shows that four of our essential elements were not covered in the aforementioned definition.

About the crowdsourcing platform element, our systematic review showed that platforms are essential and its usage can interfere directly in the results obtained and in how the crowdsourcer will design his project, manage the crowd, apply incentives, and control the quality. Estellés-Arolas & Guevara (2012) had a different view because they evaluated crowdsourcing systems instead of crowdsourcing projects, thus, studying crowdsourcing projects allowed us to perceive that systems and platforms are an essential element, rather than being the main entity of the projects.

We also defined that the crowdsourcing platform should execute two primary functions: (i) Worker management and (ii) task management. We describe these features below (ASSIS NETO; SANTOS, 2018):

1. Worker management: Function responsible for recruiting workers according to the criteria defined in a project, realizing filterings and forwarding the selected workers

Table 17 – Comparison between our essential elements and the integrated crowdsourcing definition

Elements	Crowdsourcing Definition (ESTELLÉS-AROLAS; GUEVARA, 2012)
Crowdsourcer	[...] an individual, organization, or company with enough means[...]
Crowdsourcing Platform	Not considered.
Worker	[...] group of individuals of varying knowledge, heterogeneity, and number [...]
Task	[...] The undertaking of the task, of variable complexity and modularity, and in which the crowd should participate bringing their work, money, knowledge and/or experience [...]
Recompense Mechanisms	[...] The user will receive the satisfaction of a given type of need, be it economic, social recognition, self-esteem, or the development of individual skills [...]
Control Activity	Not considered.
Project Workflow	Not considered
Asset	Not considered
Product	[...] the crowdsourcer will obtain and utilize to their advantage that what the user has brought to the venture [...]

to the task management function. This feature is also responsible for distributing the rewards to the workers when these are extrinsic.

2. Task management: Function responsible for distributing crowdsourcing task to the workers and collect the task results.

It's noteworthy that a single platform can execute these two features, as frequently done in projects that use the Mturk platform. However, distinct platforms can perform these functions, as approached by the CrowdFlower platform, which executes the task management while outsources the worker management to other general-purpose platforms, including the Mturk platform. Projects that use distinct platforms to run these two features are presented in the following studies: (MCALLISTER BYUN; HALPIN; SZEREDI, 2015; NGUYEN-DINH et al., 2013).

Regarding the crowdsourcing workflow, as stated in Chapter 1, our view of a crowdsourcing workflow is broader than some definitions found in the state-of-the-art. The crowdsourcing workflow is context-oriented and should represent the planning and coordination done by the crowdsourcer in the entire project, instead of only facilitating decomposing a complex task into subtask sets, managing their dependencies, and assembling their results.

Quality control is a crucial part of crowdsourcing projects and must be mentioned when defining the crowdsourcing term. It is not possible to guarantee that anonymous participants will produce reliable results (KIM et al., 2011; CAO; CHEN; JAGADISH, 2014; ALTMEYER; LESSEL; KRÜGER, 2016). The activities related in Chapter 3.2.6 were applied in crowdsourcing projects to address quality issues and control the quality during each step of the project. To guarantee reliable results, the crowdsourcer should understand these activities and apply the ones that best fit into his project.

Moreover, we discuss how we addressed the crowdsourcing conceptual modeling issues related by Lukyanenko & Parsons (2012). These issues were presented in Section 2.3:

1. "How can crowdsourcing conceptual models represent the diversity of views and accommodate a variable level of expertise?"

   We represented the resulting diversity of views by observing crowdsourcing projects presented in 72 indexed papers, published until May 2017. Our previous review allowed us to perceive individual opinions of numerous crowdsourcers and project designers.

   The conceptual model proposed in this paper is the result of observing crowdsourcing projects designed and sponsored by a considerable number of crowdsourcers with a variable level of expertise in the crowdsourcing domain.

2. "How the crowdsourcing domain changes the role of conceptual models as a facilitator of user-designer communication?"

   We changed the role of conceptual models in crowdsourcing projects by considering three ways of using them. First, the general structural conceptual model can be used by researchers and crowdsourcers to understand the essential elements of a crowdsourcing project and its relationships. Second, we propose the use of behavioral conceptual models (activity diagrams) to clearly define each project workflow. Finally, both the structural and behavioral conceptual models can be used as the basis for developing specifications and support crowdsourcing projects.

3. "What type of information should a crowdsourcing conceptual model specify?"

   Our general-purpose conceptual model specifies general information about the crowdsourcing domain and the role of each component of crowdsourcing projects. Also, our approach defines how the crowdsourcer can extend our model to represent specific crowdsourcing projects with individual workflows, by means of activity diagrams.

In this Chapter, we presented and discussed our conceptual model for crowdsourcing projects. This model was designed according to the knowledge leveraged in the systematic review presented in Chapter 3, which allowed us to highlight and represent in our model important concepts of the crowdsourcing domain, that were neglected in classic crowdsourcing definitions. Hence, contributing to the state-of-the-art.

5 Conclusion

This MSc dissertation presented a general-purpose conceptual model for crowdsourcing projects which was designed based on the knowledge gathered by studying the state-of-the-art of crowdsourcing and on the results of a systematic literature review of crowdsourcing projects, presented in Chapter 3.

By evaluating known studies in the state-of-the-art of crowdsourcing, four pertinent questions emerged, which could be answered after studying the crowdsourcing domain by the viewpoint of individuals that seek to solve problems using the crowdsourcing method:

1. Besides platforms and systems, what are the essential elements that participate in a crowdsourcing project?

   R: We defined nine essential elements that are mandatory for crowdsourcing projects. These elements were presented in Chapter 4.

2. How the humans are guided through the steps for solving the proposed problem?

   R: We observed that the crowdsourcer should always define a project workflow, who represents step-by-step what must be done to generate the desired product. This workflow will contain tasks that will be executed by humans and other activities that will process their results to generate a product.

3. How to ensure the quality of the results produced in all stages of a project?

   R: The project workflow is also composed of control activities, which are responsible for managing the quality during the entire workflow. Tendencies related to these activities were presented in 3.2.6.

4. Are there guidelines or models in the state-of-the-art to help newcomers creating their own projects?

   R: As a result of both systematic reviews presented, in Section 2.2 and Chapter 3, there are no widespread guidelines and models to help newcomers in this domain.

Considering some neglected concepts emerged when answering the questions above, such as elements that are mandatory to every project, a broader view of crowdsourcing workflows, and the quality management during the entire project. The general-purpose conceptual model presented took into consideration all of these neglected concepts, presenting them in all of the class diagrams shown in Section 4.1.

The relevance of our contribution to the state-of-the-art is shown in a systematic review presented in Section 2.3. This systematic review pointed out that little attention has been paid to develop conceptual models in this field of study and, to the best of our knowledge, there is no crowdsourcing conceptual model focused on defining crowdsourcing projects in a general way.

The proposed model also specified their relationships and interactions, in both the planning and execution stages of projects in this domain. By dividing the conceptual model into planning and execution models, it gives a clear understanding of what should be planned first in the project and then model its execution by creating instances of the elements already planned. Moreover, we also present a model that unifies both planning and execution models, which allowed us to show how these two stages of a project are related.

During our modeling process, we perceived that a crowdsourcing workflow usually is unique in each individual project and it represents a flow of activities that should be executed to generate a product using crowdsourcing. Therefore, a structural conceptual model cannot represent it properly.

Given that, we addressed this modeling issue by suggesting that the crowdsourcer design a behavioral model, or other models/approaches that can represent the project workflow in a proper way. This kind diagram should define step-by-step the set of tasks and control activities that compose the project workflow. Section 4.2 presented the usefulness of activity diagrams to define the execution of crowdsourcing workflows by representing and explaining how projects found during our survey were executed. Also, this section presented that crowdsourcing workflows can be executed in parallel or sequential ways.

To validate this assumption, we presented in Section 4.3 a case study that used our structural conceptual models and the knowledge of the crowdsourcing domain, provided by our systematic literature review, as guidelines to plan and execute a crowdsourcing project with an iterative and cascading workflow. Despite not creating its own instance of our structural model, it helped the crowdsourcer of this project to understand the constraints and relationships of the essential elements of the project, during both the planning and execution stages. Also, it helped in the creation of an activity diagram to represent the workflow execution of this project.

As limitations of this study, both systematic literature reviews presented were limited because they exclude MSc and PHd thesis, white papers, commercial projects, and other papers that we did not have access.

Moreover, some concepts that can be important for some crowdsourcing projects, such as the number of workers and contributions needed, synchronization, task execution time, worker reputation, control activity efficacy, and other execution details were not approached because more studies are needed to abstract these elements and model them in a general way. Also, the context element that was presented as a black box and only its relevance was alerted, it can be better elaborated in a general way.

Furthermore, despite evaluating it in a project executed *in loco*, more studies and applications are needed to keep evaluating and improving the proposed model, thus possibly finding important concepts that were not modeled.

It is also noteworthy that we focused our efforts in modeling crowdsourcing workflows that have an explicit start and end. However, we wish to further evaluate continuous crowdsourcing projects, such as the Wikipedia[1] project.

As future works, we wish to keep applying our model in practice to evaluate it. An important evaluation that we wish to do is to ask a study group that is not related with ours to instantiate it and develop a crowdsourcing project based on our model. This evaluation is important to avoid biased validations.

Other applications that can be done are the development of a crowdsourcing platform that support crowdsourcing projects based on our model. Also, it is possible to develop a code/project generator based om the proposed conceptual model.

Another future work is to keep evaluating the use of behavioral conceptual models and other approaches that can represent individual crowdsourcing workflows. A viable option is to use Business Process Model and Notation (BPMN), as shown in (BOZZON et al., 2014). Also, by evaluating other options to represent workflows, it can help us to model continuous crowdsourcing applications, such as the Wikipedia and Waze[2].

Also, we wish to perform an ontological analysis to evaluate the semantics of the proposed conceptual model. This analysis helps make intended meaning more explicit, thus improving human understanding and reducing the cost of integration (WELTY; GUARINO, 2001).

1 wikipedia.org
2 waze.com

Publications

As a result of this study, a systematic review of crowdsourcing projects that was performed to create a knowledge base about this domain and find neglected concepts in the literature was already published:

- ASSIS NETO, F. R. A.; SANTOS, C. A. Understanding crowdsourcing projects: A systematic review of tendencies, workflow, and quality management. Information Processing & Management, v. 54, n. 4, p. 490 – 506, 2018. ISSN 0306-4573.

A second publication regarding the conceptual model designed is a work in progress at this moment.

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