

Czech University of Life Sciences Prague

Faculty of Economics and Management

Department of Information Technologies



Bachelor Thesis

Crowdsourcing in Software Development

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CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

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BACHELOR THESIS ASSIGNMENT

Md Sahadat Hossain Sagor

Systems Engineering and Informatics
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Thesis title

Crowdsourcing in Software Development

Objectives of thesis

The main objective of the thesis is to analyze and compare crowdsourcing approaches to software development.

The partial goals of this thesis are the following:

- review different approaches of crowdsourcing
- analyze the possible benefits of crowdsourcing as a software development strategy
- outline the process of adoption of crowdsourcing by software development organizations

Methodology

The methodology of the theoretical part of the thesis will be based on the literature overview of relevant scientific sources regarding the implementation of crowdsourcing in software development organizations. Relevant data will be collected and analyzed from some of the organizations that already used crowdsourcing. A case study will be conducted to establish the possible benefits of adopting crowdsourcing approaches. Conclusions and recommendations will be formulated based on the synthesis of the literature review and the practical part.

The proposed extent of the thesis

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Crowdsourcing;Software Development;Open innovation;Outsourcing;Community of practice

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Klaas- Jan Stol; Bora Cagalayan; Brian fitzgerald; Competition-Based Crowdsourcing Software Development: A Multi- Method study from a customer perspective; March 2020

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Declaration

I declare that I have worked on my bachelor thesis titled "Crowdsourcing in Software development" by myself and I have used only the sources mentioned at the end of the thesis. As the author of the bachelor thesis, I declare that the thesis does not break the copyrights of any person.

In Prague on 15/03/2021

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Crowdsourcing in Software development

Abstract

Software development is the process of creating a new innovative and efficient product. The involvement of crowdsourcing approaches in this area brings new changes. As the crowdsourcing approach of software development differs fundamentally from the usual procedures, this work is mainly focused on the analysis of aspects specific to this innovative approach. The purpose is to thoroughly map the various forms of crowdsourcing, the benefits of its adoption and the possibilities of various forms of involvement of crowdsourcing principles in the field of software development. The work analyzes the collected data related to different types of software development to create a holistic view of this issue. The practical part examines two cases of software development with the help of crowdsourcing, which are the platforms TopCoder and Upwork. Both of these approaches are analyzed and their advantages and disadvantages are compared. TopCoder organizes many online competitions during which new innovative software is developed, while Upwork works on software development based on individual projects with an emphasis on reducing costs and speeding up development. The innovative crowdsourcing models of both platforms have a major impact on the changes currently taking place in the software development industry. Organizations that implement any of the discussed approaches thus gain the opportunity to increase their efficiency and gain greater benefits.

Keywords: Crowdsourcing, Software development, Open innovation, Outsourcing, Community of practice.

Crowdsourcing ve vývoji softwaru

Abstrakt

Vývoj softwaru je proces vytváření nového inovativního a efektivního produktu. Zapojení crowdsourcingových přístupů v této oblasti přináší nové změny. Jelikož se crowdsourcingový přístup vývoje softwaru zásadně liší od běžných postupů, je tato práce zaměřena zejména na analýzu aspektů specifických pro tento inovativní přístup. Účelem je důkladně zmapovat různé formy crowdsourcingu, výhody jeho přijetí a možnosti různých forem zapojení crowdsourcingových principů v oblasti tvorby softwaru. Práce analyzuje nashromážděná data týkající se různých typů vývoje softwaru pro vytvoření celistvého pohledu na tuto problematiku. Praktická část zkoumá dva případy vývoje softwaru s pomocí crowdsourcingu, kterými jsou platformy TopCoder a Upwork. Oba tyto přístupy jsou analyzovány a srovnány jejich výhody a nevýhody. TopCoder pořádá mnoho online soutěží během kterých dochází k vývoji nového inovativního softwaru, zatímco společnost Upwork pracuje na vývoji softwaru na základě samostatných projektů s důrazem na snižování nákladů a časového urychlení vývoje. Inovativní crowdsourcingové modely obou platforem mají zásadní dopad na změny, které v současné době probíhají v odvětví vývoje softwaru. Organizace, které zavedou některý s diskutovaných přístupů tak získávají možnost zvýšit svoji efektivitu a získat vyšší užitek.

Klíčová slova: Crowdsourcing, vývoj softwaru, otevřená inovace, outsourcing, komunita praxe.

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1. Introduction

This is an era of information technology. All information technology giant companies are working to innovate and implement ideas to take the world in a novel way. Any technology product is expensive to develop or implement. Therefore, it is difficult for a small company to launch a new technology start-up that has limited funding. Besides, many companies are working to reduce product development costs. Different forms of product development have been proposed where crowdsourcing is one of them which has already been implemented in various fields. The terminology “Crowdsourcing” has been introduced by Jeff Howe and Mark Robinson in 2006 (Whitla, 2009). The official definition of Crowdsourcing came from Jeff Howe and he has outlined that *“the act of a company or institution taking a function once performed by employees and outsourcing it to an undefined (and generally large) network of people in the form of an open call”* (Howe, 2007). Crowdsourcing has been adopted in many other industries where it has been widely implemented in the software industry.

Crowdsourcing is a sourcing model where individual or organizations obtain goods and services such as ideas, financing, task or completed project from a large community of users. It divides work among participants to achieve the task or get results. For example, there are lots of crowdfunding sites on the internet, where people can share their ideas with potential donors and raise money to implement them. Crowdsourcing in software development means that you are getting a solid service from a volunteer online community than from traditional employees or suppliers. It has developed rapidly over the last decade and can be closed or open source. Also, it is making waves in most industries. Nowadays, Crowdsourcing is used to produce large-scale and community-based peers of information, knowledge and culture. It is being used for various purposes such as content creation, innovative design, data analysis, development, and testing. The general motivation of crowdsourcing is to harness the creative energy of volunteer participants with little or no financial indemnification or formal managerial structure.

The process of crowdsourcing is that an organization or company proposes a task to a community of talent for outsiders who are invited to perform the task on behalf of the firm for a definite fee. The crowd of talent is open to everyone interested in performing this task. The organizer or organization will set the time and a limited number of people to perform this task. Upon completion of the work, they will assess the quality of work and if they are satisfied then they will make payment to the member. The task can be completed by many users and they will

be paid, or it can be done by one person who will be announced as the winner of the competition. The best way to publish a task online is where people from all over the world can view and perform the task. Now, more than 500 developers can build a web browser from scratch in one weekend. A major software company can fix core vulnerability across 100 systems in two hours and that is only possible due to crowdsourcing. They have a lot of contributors who are contributing to complete all phases of the development cycle. It reduces a lot of costs and time for an organization especially for a startup company that does not have enough funds to hire more people to lead the company ahead.

This form of development can save millions of dollars, time and increase more productive development activities. It can also increase the potentiality of a developer as many developers work on different activities of software or technology. Outsourced developers try to make their work as unique as possible so that the company accepts their solutions and pays them. Also, the company is benefiting from getting the best solution from the crowded participants instead of hiring too many staff to complete any task. There are different types of crowdsourcing that have been applied in the software industry. In modern times, the uses of crowdsourcing development are growing rapidly.

2. Objectives and Methodology

2.1 Objectives

The main objective of the thesis is to analyze and compare crowdsourcing approaches to software development. The partial goals of this thesis are to review different approaches to crowdsourcing, to analyze the possible benefits of crowdsourcing as a software development strategy and to outline the process of adoption of crowdsourcing by software development organizations.

2.2 Methodology

The methodology of the theoretical part of the thesis was based on the literature overview of relevant scientific sources regarding the implementation of crowdsourcing in software development organizations. Relevant data has been collected from some of the organizations that use crowdsourcing. The data has analyzed after collecting the relevant data. A case study has been conducted to establish comparisons between these organizations and the possible benefits of adopting different crowdsourcing approaches. Finally, by synthesized the practical part and considered the outcomes of the literature review, conclusions and recommendations have been formulated.

3. Literature Review

Since its inception, most people are not very aware of it. A large percentage of people know about crowdsourcing, but most people are not familiar with different forms of crowdsourcing. Crowdsourcing has widely implemented in some organizations and has many more advantages. This literature review will explain more about crowdsourcing, the process of crowdsourcing, and the uses of crowdsourcing in software development.

3.1 Definition of Crowdsourcing

In simply words, Crowdsourcing is the practice of taking a crowd or group for a standard goal such as innovation, problem-solving, or development. It is the process of knocking individuals or groups, paid or unpaid, into a group that is associated with a value interest in bringing about impressive enhanced results through their combined activities. Many authors have defined it in several ways. According to How's definition, a large connected workforce and the open call method are the two preconditions for crowdsourcing (Mao, 2015). Crowdsourcing is an open innovation and open-source form of development. Any organization can propose any project or task to the crowd and they can perform the task through the crowdsourcing platform. Wikipedia would be the best example of this. This is an open-source website where everyone is welcome to write and update anything based on specific topics. Open-source software always allows developers to create, delete or modify code and they can modify the code appropriately (White, 2019). A few other examples are the Linux operating system, Firefox browser etc.

The terminology of crowdsourcing has attracted significant attention, the underlying concepts are found in many earlier attempts to hired outside skilled people in the workforce to complete the task. We can find crowdsourcing back in longitude competition in 1714, (Mao, 2015) when the British government announced an open call competition with monetary rewards for developing a method to ascertain the ship's longitude accurately. On the other hands, we can simplify the definition to get a better understand that any organizations invite the crowd to take part in innovative work and they will give prizes and create the best ideas that come from the crowd. Crowdsourcing helps us to find talented, creative and useful ideas, knowledge for companies. it is a phenomenon that is utilized in various marketing activities such as development, advertising, publicity as well as market research.

If the context of a project is well described and therefore the crowdsourcer can identify the expected results, the most suitable crowdsourcing model can be selected and the expected value can also be met.

3.2 Elements of Crowdsourcing

Crowdsourcing is a model of taking advantages from a group or crowd by outsourcing specific task or goals provided by any company or organization. Crowdsourcing can be described with three elements. (Saxton, 2013). These are Crowd, Outsourcing and Social web. Figure 1 describes these elements below.

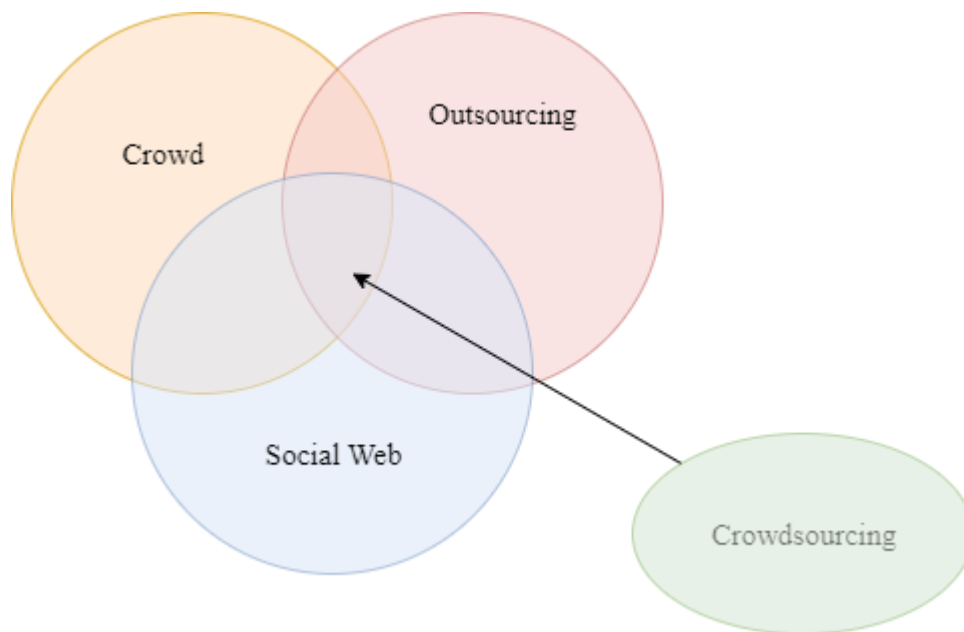


Figure 1: The Three Defining Elements of Crowdsourcing (Saxton, 2013)

Source: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2187999

3.2.1 Crowd

Crowd means that many people or group are gathered to achieve a goal or to perform a common task. Most people are gathered together for a common purpose. The crowdsourcing model needs an online crowd to find talented people to accomplish their needs. In the crowdsourcing model, the crowd plays the role of service providers, problem solvers and innovators. It is one of the oldest methods of combined intelligence. The model of crowdsourcing switches to scale through an undefined, professional and heterogeneous “crowd” online to address these criteria. (Saxton, 2013)

3.2.2 Outsourcing

Outsourcing is a way of hiring a different person, people, or a group outside of an external company to perform a task. This is a way of completing a specific task by another person or group that is not involved with a particular organization. Any researchers have defined it in different forms but according to Lacity and Hirschheim, “*outsourcing, in its most basic form, can be conceived of because of the purchase of a decent or service that was previously provided internally from outside providers*” (Lacity, 1993). Outsourcing helps organizations to focus on core aspects of the business, find out people from other organization to solve their unsolvable problem. In information technology, outsourcing initiative with an innovation provider can include the task of completely separating easily defined elements from IT functions, such as software design, network architecture, or QA testing.

3.2.3 Social Web

Crowdsourcing has reached many people or groups through this technology. Social web technology is a great invention of this age of modern technology. All organizations are using the social web to publish any online competition or work and people are being informed through the web service. The social web, commonly known as a social networking website, is an online platform where interested people can gather to share their thoughts, allusion, and opinions (Weber, 2009.) Even now, most people rely on the social web as most of the trade has been transformed into web-based. Now, people are more interested in developing web applications than developing desktop software. Organizations are using outsourcing to communicate with talented people from the crowd through the social web. All the elements of crowdsourcing are playing an important role in this. Crowdsourcing cannot be performed without these components.

3.3 Forms of Crowdsourcing

To properly understand crowdsourcing, we need to understand different types of crowdsourcing because people are using different types of crowdsourcing. Many forms of crowdsourcing are available for use in an organization. Selecting the appropriate form of crowdsourcing depends on specific tasks and goals. According to Jean, there are ten types of crowdsourcing are available (Lebraty, 2013). Some of them are- Crowdvoting, Crowdcreation, Crowdwisdom, Crowdfunding, Crowdjobbing, Crowdauditing. The author describes a few forms that are most commonly used below.

3.3.1 Crowdfunding

Crowdfunding is defined as a resource that allows a project's inventor to raise finance from the crowd (Lebraty, 2013). This is a popular form of crowdsourcing. When an individual or organization proposes a project online with a purpose and goal and requests funding, people will see if they are interested in the project and they can join the project by sharing a fund. This is a great way to use this form, any person or organization can start a project with their innovative ideas. If a startup organization or individual lacks the funds to implement their ideas, they can get funding for this project from someone or an organization with the same purpose. Some examples of crowdfunding are Kickstarter, GoFundMe.

3.3.2 Crowdwisdom

This form is used by individuals or organizations to seek opinions and thoughts from the public on any subject. Crowd experts are participating in it by sharing their opinions. Through this process, organizations can make the best decision based on expert's opinion. The key principle of crowdwisdom is to utilize knowledge about people's incredible problems or to directly predict future outcomes to aid corporate strategy. Samples of crowdwisdom including idea jams and prediction markets just like the Iowa Elections Market, Hollywood exchange and Sim Exchange. A great example is CrowdWisdom 360 (CrowdWisdom360, 2020), which is India's first prediction to host some market game to test the wisdom of people on various topics. The concept of this platform to change the price which makes the game more exciting than other platforms.

3.3.3 Crowdcuration

This is a form of crowdsourcing where the idea is to create something from an individual to a TV commercial, to solve problems or to create an invention. It helps organizations to develop new products, services, technology-related ideas. An example is Nasa's space robotics challenge where hundreds of software developers contribute their time and efforts to build up an algorithm to make life easier for those suffering from epilepsy and other neurological conditions (Fournier, 2019). More examples are-

iStock Photo - Many non-professional photographers contribute high-quality photography images.

Incentive - A community of scientists are connected with many research organizations.

3.3.4 Crowdvoting

Crowdvoting leverages the community of people's verdict to filter, rearrange content like newspaper articles, TV-shows, and films. Crowdvoting is a popular form of crowdsourcing that can generate the right levels of participation opportunities. The community perform votes through the internet which can offer a variety of voting methods. Google's worm is formed upon the principle of Crowdvoting. Threadless.com uses crowdvoting to make a decision on which T-shirts need to be manufactured and sold on its computer (Hammon, 2012). This platform was invented to meet consumer demand for innovative products before making investment decisions on new SKUs and also tried to avoid the "Power Laws" that generally apply to driven industries such as fashion and entertainment. Dell even asks the crowd to submit their designs to create fancy products at IdeasTorm.com. (Hammon, 2012) Users generate ideas but the evaluation and decision come from the organizer. The company evaluates all submissions and selects the best from them.

3.4 Software Development

Software development is the process of knowledge in a focused way as progressive knowledge can be read and executed by a computer in a centralized way (Leicht, 2015). It is also a process of controlling, design, planning, structuring the development of information system. The software itself is the set of instructions or programs that can provide instruction to the computer on what to do. It is a set of independent hardware that makes a computer programmable. There are three basic types of software which are system software, programming software, application software (IBM, 2020).

1. **System software** provides the core functions such as disk management, utilities, operating systems, and operational needs. It is also called the operating system that controls the hardware components of a computer such as the BIOS, the kernel.
2. **Programming application** provides tools such as compilers, debugger, and other tools to create software development code. Programmers are using this application to create programs.
3. **Application software** helps users for performing tasks on their mobile or computers. Examples of application software are various types of applications such as data management, web applications, security applications, office productivity suites.

Software development is usually conducted by programmers, software engineer and software developers. It is the process of build computer programs. The aim of the software development process is to build effective products for users.

3.5 General process of Software Development

The point of software development is a process to build new innovative and effective products. The general approaches of software development follow a cycle that includes a period of Requirements analysis, Designing, Implementation, Testing, Deployment and Maintenance (Figure 2) (Schach, 2007).

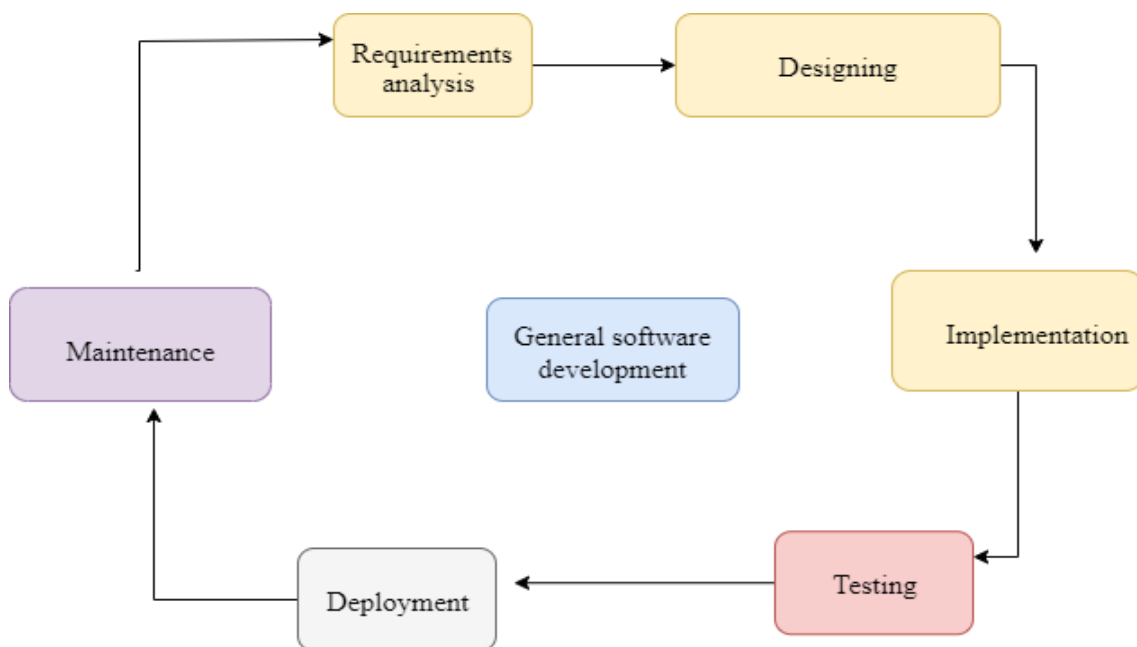


Figure 2: General software development (Schach, 2007)

Source: <https://www.amazon.com/Object-Oriented-Classical-Software-Engineering-Stephen/dp/0073376183>

- 1. Requirements analysis:** The idea during this period is to explore the needs of the clients. It is presented in a form that analyzes the needs of the clients to verify their requirements and it helps to deliver the product to the client.
- 2. Designing:** At this stage, the requirements are transferred to any form for architectural design. The design of the software is created as a software design document (Hasteer, 2016).

3. **Implementation:** All components are transferred from the design document to coding during this period.
4. **Testing:** After implementing the code, the developer tested the product through unit, integration and whole system testing and if they found it correctly, they provide it to the client to test it for acceptability.
5. **Deployment:** At this stage, the successful software tested with its specifications is provided to the client.
6. **Maintenance:** This period begins after the delivery of the product to the clients. It needs maintenance due to any changes or errors. Sometimes it even takes a certain amount of time to fix the errors. Then they test the product to check for bugs and errors and to maintain the functionality of the system, but this only happens at the request of the client.

3.6 Crowdsourcing Software Development

Crowdsourcing is an emerging form of problem-solving which is typically online and depends on a large number of people to solve tasks (Sherief, 2014). Crowdsourcing software development means an open call for the community of talent to participate in any part of software development such as design, coding, implementation and testing. This is a great invention in software development to reduce organizational cost, time and increase productivity. It brings a new innovative concept in software development from the community of talent. Many authors argued that crowdsourcing promotes creativity and problem-solving. However, crowdsourcing has many more unique features.

In this era of cloud computing, big data, web application, software development has been changed a lot. Organizations and software companies with software users have called for better integration for ease of use, shorter development and operation (Leicht, 2015). Crowdsourcing Software Development has transformed the paradigm of software development from general software development to crowdsourcing based development (Huhns, 2013). Any enterprise company can outsource the skilled crowd to develop software competitively.

3.6.1 The process of adopting crowdsourcing

The adoption of crowdsourcing is increasing rapidly in various sectors of industry. According to (Qin S., 2016), four key business challenges need to be considered before adopting crowdsourcing which is- Prescribe the needs, Discovering the right experts, Filter response, Managing terms of the agreement.

1. **Prescribe the needs/problems:** Mostly a supplier can understand the problem better than the buyer, so it is difficult for the non-expert buyer to find out the need/problem. Hence, clients can get support from a crowd through an online platform to define their needs. They will get help from the crowd to receive an appropriate solution. Finding the right platform is a complex task that can offer them expertise people to meet their specific needs.
2. **Discovering the right experts:** It is still difficult to contact an expert solution provider to fulfil their needs. Hence, they need to find out an expert from a crowd through an appropriate platform. It needs to be an open call within a web-based platform where expertise people are invited to join the community.
3. **Filtering responses:** Once the proposal is published in the online community, it can be difficult for the buyer to evaluate the response of the various solution providers. The mediator helps solution seekers with expert knowledge to filter out the right solution and select with the greatest potential (Qin S., 2016).
4. **Terms of agreement:** Once an organization has filtered out their issues, experts and response, they need to choose the form of crowdsourcing that they follow to finish the project. Besides, they also need to specify the duration and payment of the project. They end up in an agreement with proper systems, billing and pricing arrangements.

Crowdsourcing not only active for the diverse potential crowd of users but also actively controls the management system of the online community. Crowdsourcing attracts expert people for participation to open source contest, challenge with attractive rewards and to attract company for adopting crowdsourcing to fulfil their specific needs at low cost and within a short period. Figure 3 shows the process of crowdsourcing as Ke Mao has described in his article (Mao, 2015).

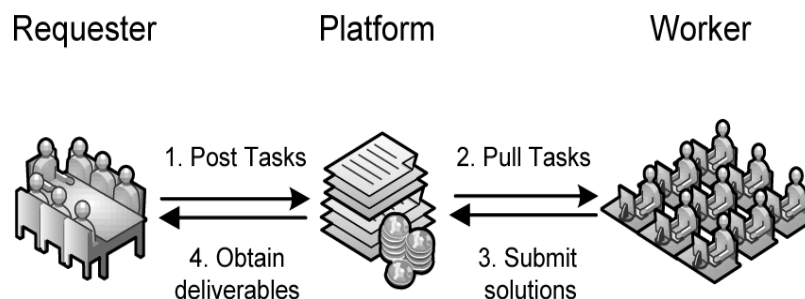


Figure 3: An overview of crowdsourcing. (Mao, 2015)

Source: <https://www.sciencedirect.com/science/article/pii/S0164121216301832>

Some of the company has already adopted crowdsourcing for software development and developing tools, design, quality assurance, testing. Several websites already established using crowdsourcing such as AppStori, oDesk, mob4hire, TopCoder, uTest. Some giant software companies like Microsoft, Amazon, Apple and Oracle are actively involved in crowdsourcing. Microsoft used crowdsourcing to develop Windows 8, and Oracle was used to provide architectural and model guidance for the development process (Huhns, 2013).

3.6.2 Approach of Crowdsourcing Software Development

Crowdsourcing is outsourcing to an individual through an online platform so that everyone can participate. Organizations need to follow some steps to execute this process. Some of the approaches are available for crowdsourcing software development which is proposed by the organization. Some company are organizing a competition and some organizers simply offered a job or work on an online platform and are looking for someone out of the crowd who can do the job for their specific needs. Here (figure 4) the author describes one of the general approaches of crowdsourcing software development.

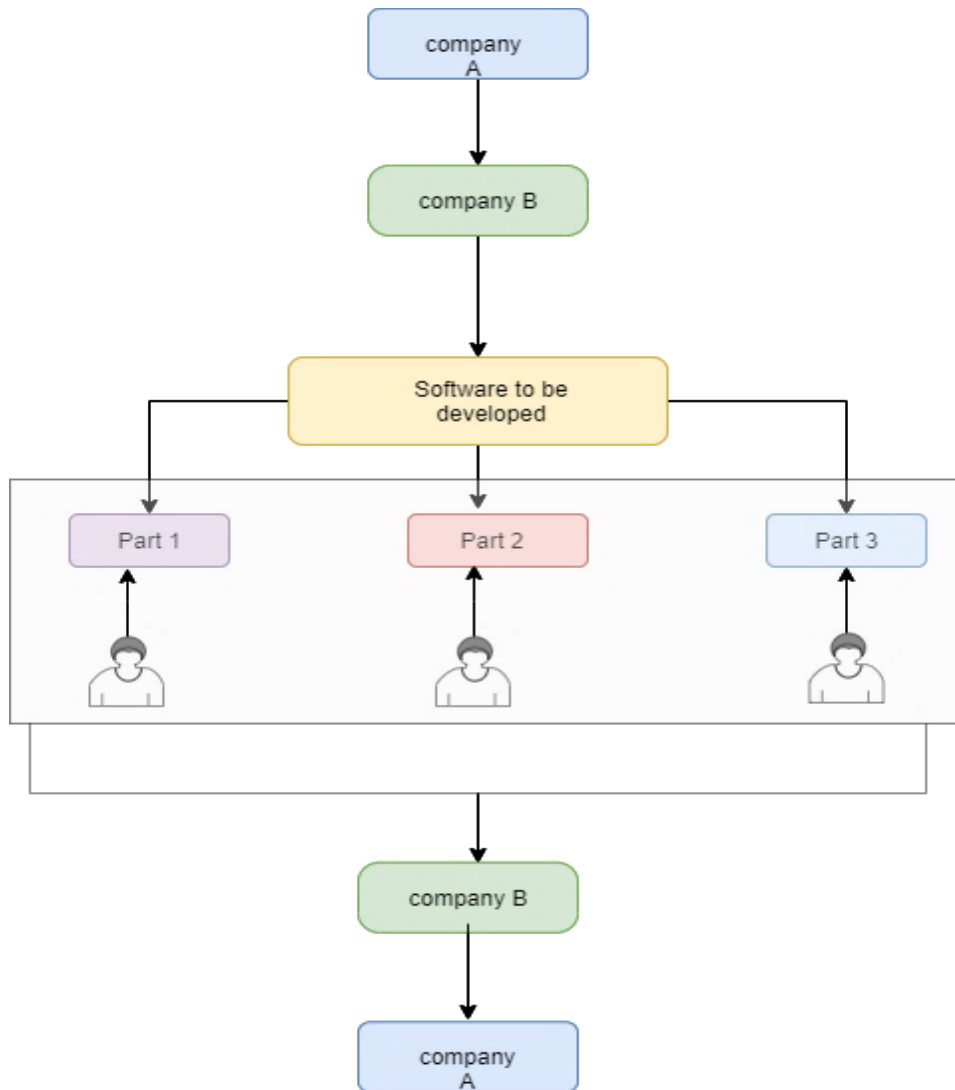


Figure 4: Overview of the approach (Usui, 2016).

Source:

https://www.researchgate.net/publication/267782479_An_Approach_for_Crowdsourcing_Software_Development

According to (Usui, 2016), the detailed procedure of this approach is as follows:

- Company A wants to develop software, so they request company B to develop the software. Company B post the entire task or part of the task to the crowd.
- Company B divides the entire project into one or more parts including specific requirements and test cases. After that, they publish the proposal on the online crowdsourcing platform. The proposal includes specification requirements and use cases.

- Individuals or groups may develop software as well as requests for specific requirements and tests. They must agree with the budget as they have requested a proposal with a specific budget. They can provide their experiences and previous achievements.
- Company B decides which part of the software they develop and offers to the public. Peoples from the crowd are usually connected to company B because they usually propose the task to the crowd.
- The individual design, implementation or testing of the program must satisfy the specific requirements which were given by Company B. Company B ensures the satisfaction of the program after implementation. They check individual task with specification and tested use cases as they needed.
- After testing the programs and being satisfied with the implementation of their program from individuals in the crowd, they deliver the program to Company A (Usui, 2016). Company A pays to company B and company B pays to an individual or group for their work.

This is just one way to crowdsourcing software development as many organizations follow a different approach to crowdsourcing.

3.6.3 Some companies that have adopted Crowdsourcing

Most of the companies are thinking diversity for a better future these days. Besides, the intention to implement new ideas is also increasing. In this case, crowdsourcing helps the organization to think outside the box. Crowdsourcing platforms help organizations to find the best solution from the community of talent and reduce the additional cost of product development. Performing specific software development tasks for an organization by a potential number of people or groups through an open call with rewards (Stol, 2020). Most industries are now adopting crowdsourcing. Here is a list of some of the platforms in the software industry that accept crowdsourcing and the author describes some of them in Table 1 below.

Table 1: List of platforms crowdsourced software industries (Mao, 2015)

Platform	Form of Task	Open Call Form
TopCoder	Software Development	Online Competition
GetACoder	Software Development	Online Bidding
Bountify	Small Coding Tasks	Online Competition
uTest	Software Testing	On-demand Matching, Online Competition
TestBirds	Software Testing	On-demand Matching
99Tests	Software Testing	On-demand Matching
Pay4Bugs	Software Testing	On-demand Matching
CrowdTesters	Software Testing	On-demand Matching
TestFligh	Mobile App Testing	On-demand Matching
Mob4hire	Mobile App Testing	Online Bidding
Bugcrowd	Software Security Testing	Online Competition
Upwork	Development, Design	Online Bidding

Source: <https://www.sciencedirect.com/science/article/pii/S0164121216301832>

TopCoder: TopCoder is the largest platform in terms of many members, organizations tasks as competitions (Stol, 2020). TopCoder was founded in 2001 by Jack Hughes and he is also the founder of the Tallan company. TopCoder has hosted more than 427,500 software design, development, and data science competitions, awarding more than 25,000 USD in a day to competitors (Latoza, 2016). This platform has more than 400,000 members from 190+ countries. (TopCoder, 2020). It has over 600,000 developers around the world who are participating in code software for their clients (Hasteer, 2016). It has rewarded \$36 million in prizes to its members who participated and won (TopCoder, 2020).

TopCoder is indeed a great online platform where software is produced through a competition. Giant organization like Amazon, NASA, Facebook, Box and Harvard also taking the service of TopCoder to bring innovation from a crowd of intelligence around the world through a competition. Although it is complicated processing how they are developing top software from the crowd. The development process starts from the requirements phase which includes project goals, tasks, plans, and budget. Each of the development phases is released through a series of online competitions where the group of developers compete with each other. Only qualified winning solutions are accepted from the competition.

Qualified results are accepted as the winner of the competition due to inputs from the next competitive stage. In this context, 'qualified' means achieving a minimum acceptance score rated by the TopCoder Review Board through a review process. This is an ideal example of the advantages in the world of crowdsourcing. The Topcoder community works mostly for software development, application design and development, smartphone development, testing and certification, algorithms and analysis, and more technology development services. It has brought an extensive mutation in software development industries.

uTest: uTest is an online crowdsourcing platform for software testing on real devices in real-time. It was founded by Roy Solomon and Doron Reuveni in 2007. It is the world's largest open-source community for software testing. They have over 500,000 testers worldwide, 1000 new testers a day, 2.5 million devices worldwide and millions paid to testers monthly, (uTest, 2020) which is an amazing growth of a crowdsourcing platform. Those crowd testers provide experimental services such as usability testing, functional testing, localization testing and load testing. This platform is very efficient in detecting software bugs. The platform provides testing devices and budget. It is an open call for software tester so that the crowd can apply to the task on their choices

They get paid via the platform on a per-project basis (Mao, 2015). It has the great advantage of having a training option to train new software testing enthusiasts. So those people who want to work as QA tester can learn these for free. It has been found that the offence-defence based quality is the most fundamental thanks to the elimination of potential deficiencies in documents, models and codes submitted by the crowd. Multiple community groups take on a variety of software development tasks and collaborate closely with each other to investigate their competitors' work issues and reduce errors in their work (Li, 2015).

AppStori: This is an online platform that uses crowdsourcing for mobile app development. The development process of AppStori is different from TopCoder. This platform uses crowdsourcing and crowdfunding to manage the funding for development and attracts app developers and consumers to work nearly together. The developers from the crowd can propose their projects to other developers or an organization to raise funds to implement applications. Consumers are free to propose new innovative ideas to develop a new application and contribute money to raise funds for application development (Mao, 2015). They can provide feedback on existing projects.

The entire application development process from ideation to release is achieved through collaboration between developers from the crowd and the consumers. There are over a million apps available and it is hard to find a good app. AppStori has partnered with a company called Millenial which has raised \$500 for funding and \$500 for advertising (Love, 2012). AppStori helps to find out apps that are worthy of being discovered.

Upwork: This is the most popular crowdsourcing platform around the world. This platform uses crowdsourcing for software development., design, web development, data analysis and many various types of projects. It was founded in 1999 as Elance. The name of the company was changed because Elance and oDesk agreed to work together under the name Elance-oDesk in 2013, but two years later, in 2015, they renamed it Upwork. This company has over 10 million freelancers and over 5 million registered clients (Green, 2018), over 180 countries are using this platform. It posts more than 3 million jobs annually. These talented freelancers perform in various projects such as software development, web development, graphic design, creative contents, marketing, administrative support and customer support through this platform. Upwork generates 1 billion USD worth of job on an annual basis and they cut 10 percent from a freelancer which means they can make around 100 million USD (Lunden, 2015) revenue on the market. They charge 2.75% processing fees for clients to hire people through Upwork. The registration is free for clients and service providers.

3.7 Possible Benefits of adopting Crowdsourcing

By going to an enormous gathering of individuals for new ideas and solutions, crowdsourcing can generate a lot of benefits over the internal perceptible process. Not only businesses can get new ideas through crowdsourcing, but it can also drive marketing buzz and engage their consumer. Crowdsourcing has been used successfully for many varieties of task from concept to release. This helps the company to reduce costs, get better quality, solve problems faster and get many more benefits. The rewards attract many talented people from the crowd to solve their problem and win the rewards. Some of the significant benefits of using crowdsourcing are below.

Cost reduction: Crowdsourcing helps to reduce the overall cost of development. There are overhead costs in case of general software development include hiring software developers, training, hardware, maintenance which involves software development and also there are minor costs against the project such as office space, cleaners, supporting employees like the manager, accountant and cost of established networks in the entire workplace (Hasteer, 2016).

These overhead costs can be reduced by crowdsourcing software development because crowdsourcing does not require these things. This can save millions of dollars for a company to use crowdsourcing rather than general development. A crowdsourcing platform named TopCoder claims that it reduced 30-80% cost savings over by using crowdsourcing (TopCoder, 2020).

Increase Consumer Engagement: All products are invented or created for consumers. If consumers are involved in the crowdsourcing effort, then it can expect a result an extraordinary level of consumer engagement. The most traditional marketing idea is to an advertisement of product for seeking the attention of consumers for a short period of time but asks consumers to participate in crowdsourcing to solve a specific problem can gain more valuable attention of many companies (White, 2019). A successful example would be the competition of Lays called 'Do us a flavor' where chips fans were invited to submit their best and wackiest ideas for new potato chips flavours (Fournier, 2019).

Find an unexpected solution: The most significant benefit of crowdsourcing is the ability to find out the right person to solve unexpected problems. When a company or organization finds a problem internally, it's not easy to resolve it as they have limited skilled talented people in their organization. By involving a large number of potential people is easy to solve a problem in many ways. A company can get hundreds of solutions in different approaches by using crowdsourcing. A great example is Unilever's open innovation where the company were asked expertise people to solve a difficult problem out of the box with unexpected results (Fournier, 2019).

Merits with quality: Crowdsourcing software development would result in more innovative solution as the compared traditional way of development, where the expert team is limited, but the expert team is extensive in terms of crowdsourcing. It can lead to producing more quality software due to broader participation. The ability to get accessed in a wider talented technical expertise hence could result in the best possible project on their capabilities (Hasteer, 2016).

The prize winner will be the provider of the highest quality solution so that they try their best in the competition. A variety of expertise is also an advantage in delivering different quality solutions.

Flexibility: Crowdsourcing provides more flexibility to the talented community. The talented community working online and always accessible to the community, so the time and location do not affect their work. So, since all crowdsourcing platforms are virtual, they can work anytime and from anywhere.

4. Practical part

The research has been accomplished on two different crowdsourcing platforms named TopCoder and Upwork. Relevant data has been collected from these two largest crowdsourcing platforms called TopCoder and Upwork. Both of these online platforms are using crowdsourcing for software development, design, ideas implantation, testing and many more tasks. Most archival data has been collected from companies' websites. The focus is to find out the differences between these two platforms. The research has been carried out based on some of the key factors of these platforms such as Basis of the platform, Project ideas, Dealing with the crowd, Test case preparation, finding bugs of the product, Product run and evaluation, Crowd participants, Development process, Quality assurance of the product, Scammers, Project rate, Platform charge. After comparison both of the platforms, the SWOT analysis has been performed to know the Strength, Weakness, Opportunities and Threats of these platforms.

4.1 TopCoder

TopCoder is a USA based software development crowdsourcing platform. A details overview of this company has already described in the literature review. It is the biggest crowdsourcing platform with over 1.5 million community members and as 5X more engineers than Microsoft, Twitter and Facebook combined (TopCoder Community, 2020).

4.1.1 The approach of TopCoder

The innovative business model of TopCoder went through many transformations. The approach of TopCoder is very consistent and simple. TopCoder adopted an innovative model that creating a solution for clients by hosting competition through the community. It is also possible to work on one or more project in parallel by using TopCoder. Figure 5 shows the approaches of crowdsourcing in TopCoder as described on their website.

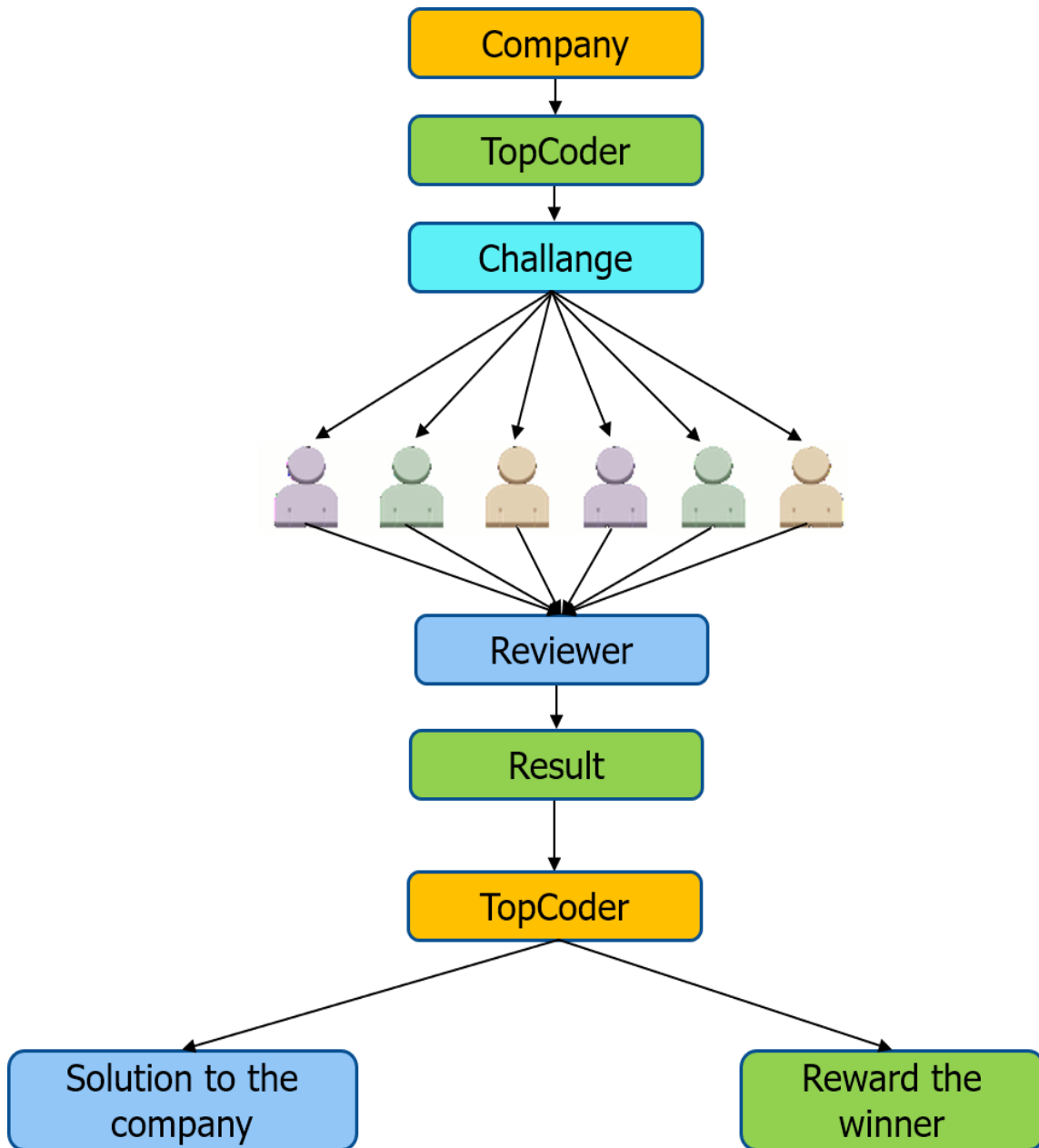


Figure 5: The approach of TopCoder. Source: <https://www.topcoder.com/>

- If any company wants to develop or design software through the TopCoder platform, they need to register as a customer in the TopCoder community then they need to contact with TopCoder team to find the solution with specific requirements. After specifying the projects, TopCoder starts working on the project by hosting a competition through their online community.

- As it is an open call competition, everyone from the community is allowed to attend the competition but before participating, the crowd of talent needs to register as a talent on the TopCoder community. Participants are requested for registration of the challenge and before the registration to the challenge, they need to agree with the terms and condition of the particular task.
- The talented crowd can get all the detail information about each challenge on the challenge's forum. After reading the requirements of the challenge and registration, they can participate in the challenge and submit their solution. The task can be done individually or in a team which depends on the challenge requirements and it is also be specified on the task. Then they will need to submit their solution on the challenge page from the TopCoder's server.
- After getting all of the submission from talents, it will be reviewed by the TopCoder review board or client-based review board. They review all of the submissions and determines the best solution. All members of the review board are paid to grade on all contest's submissions with a score so that they can determine the best solution based on the highest scorer. Afterwards, the review board hand over the result to the TopCoder.
- After receiving the result, TopCoder delivers the product to the clients and rewards the winner of the competition. Also, they have updated talents rating for their performance (Lakhani, 2010). In some challenges, they reward the best solution providers and sometimes they reward two or three best solution providers which are also described in the task details.

4.1.2 The approach for Software development using TopCoder

TopCoder follows a cycle for the software development project. They create various cycle of the process for different tasks. For developing software, TopCoder creates some phases for software development (Figure 6) which are Conceptualization, Storyboard and Wireframes, Specification, Architecture, Component design and development, Assembly, Bug hunt and race (Wu, 2013).

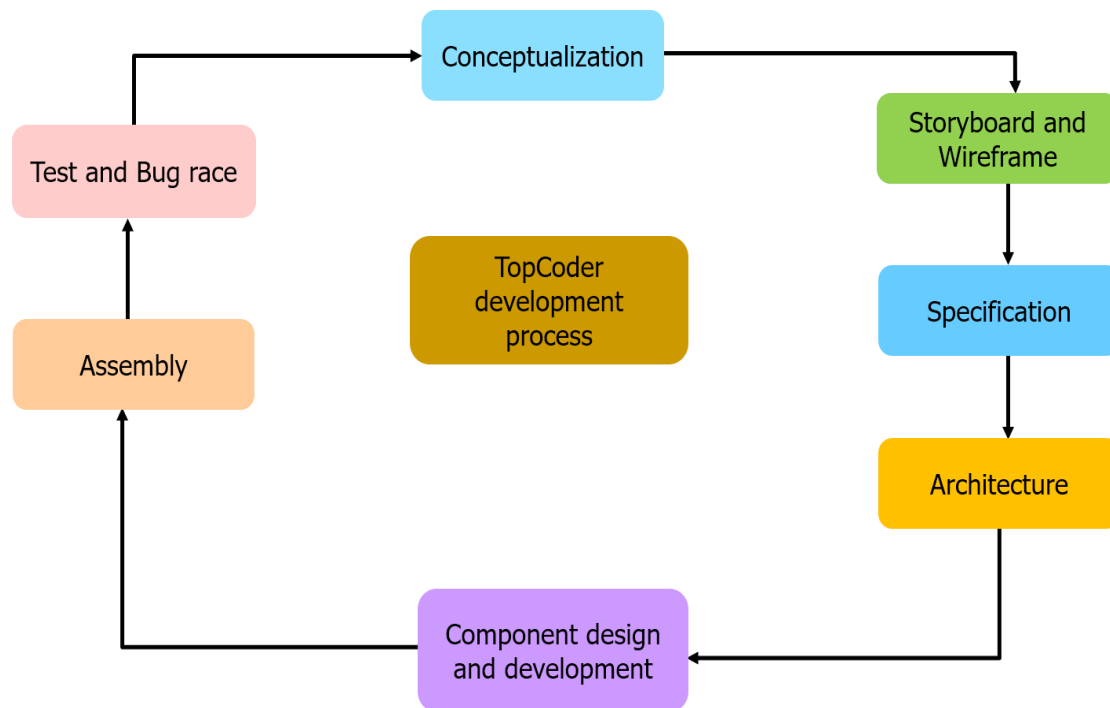


Figure 6: TopCoder software development process. (Wu, 2013)

Source:

https://www.researchgate.net/publication/264441330_Creative_software_crowdsourcing_From_components_and_algorithm_development_to_project_concept_formation

1. **Conceptualization:** It describes the initial requirements of the project including features and use cases. Project goals, high-level workflow and business requirements are described in the use cases and diagram.
2. **Storyboard and wireframes:** This step defines the information process used in the application and input to this step is conceptual documents developed and the output results are the wireframes. It also defines the web page flows, user inputs, each content of the application and UI styles of the application. Storyboard develops a high-level application view with the GUI interface.
3. **Specification:** This step describes details to provide a business requirement and set of wireframes outcome from the previous phase. This phase specified the requirements with UML diagrams such as use cases diagrams.
4. **Architecture:** In this phase, talents start to develop the application architecture including all the modules based on the product requirements. It is needed to design documents, UML diagrams and make a prototype of the architecture.

5. **Components design and development:** In this phase, TopCoder contests are asked for convert a set of architecture documents in to set of diagrams and component specification document that defines the algorithm, design pattern, class list, running environment and configuration. They have to develop specific components based on the component document.
6. **Assembly:** After the components are developed with the architecture and the functional application by linking all the components with the application flow, participants follow the previous specification documentation from the previous phases and can reuse if needed (Wu, 2013). Then they develop the software assurance plan to validate all the requirements which are implemented in code. In test suites, they automate script competition and expected to deliver automated test scripts derived from the QA plan.
7. **Test and Bug race:** TopCoder is also hosting a competition for finding bugs and fixing them. All the participants send the bug fixing reports through the competition. They need to make changes, resolve the issue and perform the validation. Also, the review board checks all the submission to choose the best solution. After fulfilling the requirement, they deploy the product.

All these phases are planned by TopCoder. Any organization that only needs to communicate with TopCoder, take responsibility and all the process to provide the best quality software to the clients. Participants need to complete all the tasks step by step and they are gaining points from these submissions. They can also get negative points for a late submission. Overall high scorer wins the rewards through this competition.

4.1.3 Advantages and Disadvantages of TopCoder approach

Advantages:

- **Access to incredible talents:** Lots of talented people are registered by TopCoder as they are willing to participate in the online competition. Any organizations can see their profile and can hire them from the TopCoder community.

- **Getting support and guidelines:** Participants can get help at every stage of the competition from the TopCoder forum. Candidates may face a problem while competing so that they can post their problems on the forum and can get solutions from experienced people through the forum.
- **Dedicated co-pilots:** TopCoder assigns co-pilots for every challenge to help participants for executing (TopCoder Solution, 2020). Co-pilots guide candidates during the competition.
- **Open competition:** As it is a free call competition, it is a great opportunity for developers to prove their talents and win rewards through the contest.
- **Upfront short deadline:** TopCoder presents the timeline for any project in upfront. Participants are asked for a solution within a specified time so that they must upload the solution until the time ends and the clients can receive the product on time.
- **Best solution:** The significant advantage of this approach is that there are many solutions to a problem and the best solution is to choose the best solution out of them.
- **Negotiation of an hourly fee:** As the project fees set by TopCoder, the client does not need to negotiate an hourly fee with talent. The amount of payment is based on the project. TopCoder deals with both clients and talents so that the company does not need to deal with it with talent.
- **Having a review board:** They have experienced a review board to review all of the submissions carefully so that clients do not need to review any submission.
- **No worries about the quality and delivery of the products:** TopCoder deals with projects with the talents for quality, testing and delivery of products so that clients do not have to worry about product quality and delivery. TopCoder always provides the best solution with the specific product needs of the clients.

Disadvantages:

- **High competition:** Winning prizes is tough because many competitors are working on the same project where only one or two people will be rewarded for the best solution. Some developers who do not win the challenge may think that it is a waste of time to work for many days without getting a single penny.

- **Payment method:** TopCoder uses three online methods named PayPal, Payoner and Western Union to pay for talents. Sometimes members face problems in delaying transfers and rejection of payments. Many members outside the United States may face tax-related problems as they follow the U.S. taxation system.

4.1.4 SWOT analysis of TopCoder

There are four elements in the SWOT analysis which are- strength, weakness, opportunities and threats. TopCoder can use their large community as a strength to create a great position in the market, can trying to reduce weakness so that they can be the best competitors in the market (Table 2). They need to look out for the opportunities provided by the development environment, industry structure, regulation and develop a strategy to relieve the threats that can undermine the business model of TopCoder.

Table 2: SWOT analysis of TopCoder

<p>Strengths:</p> <ul style="list-style-type: none"> • Mass community members. • Strong relationships with multiple organizations. • Best quality products and services. • Reusable of software components. • The best solution providers get good prize money. 	<p>Weakness:</p> <ul style="list-style-type: none"> • Rewards are not distributed among all valid solution providers. • Less active participants. • Mass participations depend on prize money. • The website is not user friendly enough.
<p>Opportunities:</p> <p>Clients</p> <ul style="list-style-type: none"> • Get access to incredible talents from around the world. • Organizations have many options to choose from. • Implementing great ideas. <p>Talents</p> <ul style="list-style-type: none"> • Increase public relations. • Great opportunities to prove their skills, learn and improve. • Well income from anywhere in the world. 	<p>Threats:</p> <ul style="list-style-type: none"> • Many competitors in similar business service. • The cause of international political factors. • Increase bargaining potency.

4.2 Upwork

Many giant companies like Microsoft, Airbnb, Bissel, Coty are registered with Upwork to get service from their registered crowd. There are three scopes for recruitment such as complex project, long-term project and short-term project (Upwork, 2020). Upwork's mission is to create economic opportunities for better lives in the community. They have set up independent professional hard working through Upwork.

4.2.1 The approach of Upwork

Upwork uses different approaches to crowdsourcing than TopCoder. Upwork's business model is very simple as they are working as a middle person between clients and service provider. They use the crowd to fulfil client's need through this platform. Their approach is very evident to both clients and freelancers. Clients can run their business in their way and clients can also respond to their intended company and projects (Upwork, how it works, 2020). Figure 7 demonstrates the approach of Upwork.

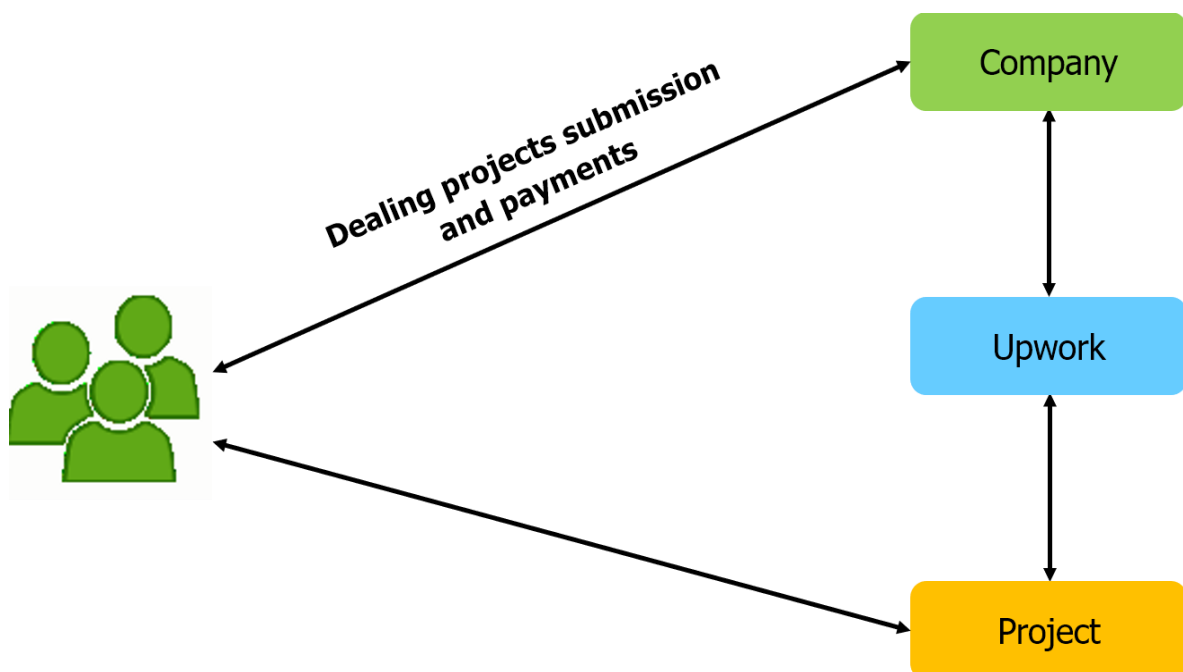


Figure 7: The approach of Upwork. (Source: <https://www.upwork.com/>)

- If any company wants to develop software or finding a solution for their company's need, they have to register first as a '*hire talent*' and then they need to post a job. Before posting a job, they have to specify about their project and specific requirements to Upwork, so that they can make the functionality using data science to get the suggestion of the best freelancer or any freelancer who is matched with their needs. The company can search for suitable candidates from Upwork and also can get a shortlist of the well-matched profile from Upwork (Upwork, how it works, 2020). They can easily review the candidate's profile and proposed with detail's information about the project.
- After posting work on the Upwork platform, it appears as a suggestion to the talented crowd that matches the talent profile using Upwork's data science. As it is an open platform, all developers can use their talent through this platform. If anybody wants to work as a talent, they have to register as "*I am looking for work*". After registered in Upwork, they need to fill up many detail's information such as study, designation, skills, work experience. They can also fill up their desired type of jobs such as software design, development, web design so that these type of jobs offers will appear as a suggestion to them. After choosing a task, they need to send a proposal to the company then collaborate regarding each specific information such as task details, deadlines and payment. Sometimes Company may ask for an interview with the talent or sometimes they may agree to the proposal after reviewing the talent's profile. Upwork charge 20% for the first \$500 bill, 10% for the talent's payment between \$500.01 to \$10,000 and 5% for the exceed \$10,000 (Upwork, how it works, 2020).
- After agreeing, the talent can start working on the project and it needs to be completed before the deadline. Talent can work alone or as a team for a big project such as software development, web development. In this case, the company only deal with team admin. After completing the project, they need to submit it to the company and the company will review the task and pay the client and be satisfied with the solution. All the invoices and payments are happening through Upwork.

4.2.2 The approach for Software development using Upwork

Upwork deals with different types of projects and the organization determines the processes for each project. The company plans all the specifications of the project and they define all the details about the project and the process will be followed by talent selection.

The author reviews some of the software development projects from Upwork in details and (Figure 8) demonstrates one of the processes of a software development project below.

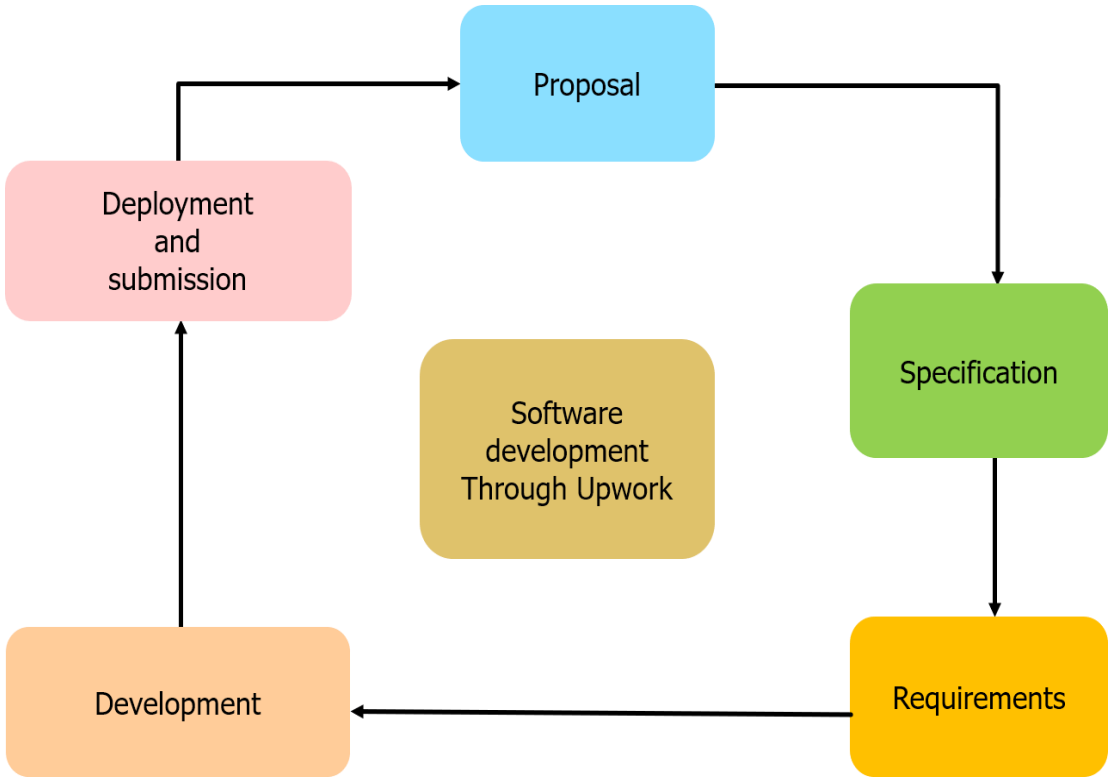


Figure 8: Process of software development through Upwork. (source: <https://www.upwork.com/>)

- 1. Proposal:** At this stage, the company proposes a software development project on the Upwork platform. Upwork is acting as a middle-man platform here. They do not conduct any initiatives for the project.
- 2. Specification:** The company specifies all the details about the project such as software design, use cases, functional requirements, system requirements and deadlines. This phase describes what and how the product should be.
- 3. Requirements:** In this phase, the company describes the equipment requirements and necessary knowledge of the particular skills of applicants. They prescribe specific tools such as programming language, framework, bugs and issue solvation that will be used in this development and the specific qualifications required to implement this project. So, to apply for this project, the applicant needs to have the skills to develop that software. After applying for the project, the company reviews the candidate's profile and interview the candidate for the selection of the project and after accepting the proposal of both parties they agree to all the terms of the project. (Upwork, 2020).

4. Development: At this stage, the candidate begins to develop the software. In this regard, the candidate can follow his way to design architecture, use cases, system features, user interface, hardware interface and software quality attributes. The candidate only has to meet all the requirements as the entity mentioned in the specification and requirements stages. If the company only hires for a few stages of the development process, they need to do the specific phase and submit it to the company.

Deployment and submission: If the candidate works for the whole project then the software bugs need to be checked by the candidate after the development and all the bugs need to be fixed before the product is deployed. The candidate is responsible for bug fixes and product placement. After successfully running the software, they can submit it to the company directly and the company pays the candidate through the Upwork platform.

All the steps of software development projects are planned by the company. They can determine the process as they prefer. If they propose complete software development, the developer can develop the product on their way to meet all requirements, or if they offer some part of the project such as software design, architecture, code implementation or any steps of development then the candidate needs to do the particular part by following the company's procedures.

4.2.3 Advantages and Disadvantages of Upwork approach

Advantages:

- **Accessed to the talented crowd:** There are many talents especially many developers who are registered with Upwork to work on their desired projects, so this is a great platform to find suitable talents/developers for a particular project.
- **AI matching technology:** Upwork also includes AI features that can send suggestions to both clients and the talent side included. This technology helps the developer to send better comparative suggestions of project development and advises the organization of better candidates for specific projects, it saves a lot of time for the client and talent to find a suitable project or the perfect candidate.
- **Allows fixed and hourly payment:** This method helps a lot as clients can choose to pay based on the project. Through the convenience of hourly rates, talents can make their every precious hour worthwhile. They can even choose a project based on their available time. This is a great advantage for both types of projects.

- **Independency:** Both the clients and talents can choose candidates or projects based on their preference. Upwork does not interfere with the selection of any candidate or project. Clients can review candidate profiles, judge their quality before contracting, and review their products after submission so that the company can ensure the perfect solution from candidates. Similarly, candidates can choose their project and company after understanding the whole project proposal and payment, so that they can reject or agree to any proposal.
- **Bidding option:** Companies offer task posts with a fixed rate and time for projects, but bidders have the option to bid with fees and time for projects. For example, an organization wants to develop software for \$300 and it has to be completed within 30 days but the candidate can bid for \$200 and 20 days by reducing the fee and time so that the company can see it and save more money and time. Many new developers are bidding to reduce the fee and time to get the project out of the huge competition of the crowd.

Disadvantages:

- **Hard to get first work:** It is really difficult to get the first job through Upwork without having previous experience or a new profile. Although previous experience does not require applying for a job, it is quite hard to convince an organization without a good profile to get big projects like software development, web development. Since software development is the most creative work in this age, companies always try to hire an experienced developer in this field. Thus, many developers cannot prove their talents and skills through this platform.
- **Lack of quality:** Sometimes clients offer a much lower rate compare to the project work so many good candidates do not apply or accept the proposal for this type of work. Even clients have to go through a lot of candidates profile and never really know if talent can do the job or not. Even sometimes clients pay more than the appropriate rate but get a lower quality product. With this approach, it is somewhat difficult to distinguish good and good quality service from the masses. Due to the high competition, people are bidding very low price for high-cost projects and they realize once the task is done.
- **Cost and fees:** Upwork is not an inexpensive platform because they charge from both sides, especially for talents when they work for a small project with little money.

The first bill would cost 20% for the first \$500 bill where most small projects cost less than \$500. Similarly, they charge 10% for payments ranging from \$500.01 to \$10,000 and 5% for the exceed \$10,000 and also as a USA based company, they have to pay taxes following the taxation systems in the United States. They charge the client 3% on the payment and they can buy plus and business plans to provide more features which are monthly \$49.99 monthly and \$849 respectively (Upwork, pricing, 2020).

- **Scammers:** After reviewing a lot of comments from the Upwork review site, the author discovered that a lot of scammers are committing fraud here. They did fake reviews from their own company to attract other companies to get the project and they provided the worst service to the clients after getting the project. Here is one review from a client for native apps and iOS development project- *"Beware. do not proceed with these guys. false promises. What they have on Upwork are not real jobs done. They have created a bunch of fake reviews using their own companies. Million dollars' worth of reviews. The loophole was well abused. Again, DO NOT proceed with these guys. They are not professional. They charged a ton but gave up at the end and blocked me when the refund was requested."* (Upwork review, 2020).

Likewise, there are a lot of complaints from the talents side as well. Here is a comment from a candidate for iOS and Android mobile app development project - *"We have been assigned app; it was almost done but project cancelled by customer realizing the legality of the app. Further our final payment was not released for our work done."* (Upwork review, 2020).

5.2.4 SWOT analysis of Upwork

Upwork is a leading platform in its industry. To retain this position, a strategic decision needs to be made using their strengths to take advantage of Upwork opportunities, eliminate vulnerabilities and overcome threats (Table 3).

Table 3: SWOT analysis of Upwork

<p>Strengths:</p> <ul style="list-style-type: none"> • A well-developed AI to match the profile. • Cost structure. • Large market value. • Qualified talents. • Superior quality service. • Innovative development method. 	<p>Weakness:</p> <ul style="list-style-type: none"> • Quality assurance. • Low budget for any product. • Less market research. • Highly qualified developers are decreasing.
<p>Opportunities:</p> <p>Clients</p> <ul style="list-style-type: none"> • Get access to large talented crowds from all over the world. • Providing many services. • Increasing globalization. • Flexible tax policy. <p>Talents</p> <ul style="list-style-type: none"> • There are opportunities to work on more projects. • Direct dealing with the company. • The appropriate rate of a project. • There are a variety of work options available. 	<p>Threats:</p> <ul style="list-style-type: none"> • Many competitors offer the same service. • Fluctuating of the exchange rates. • Having scamming has a bad effect on the platform.

4.4 Comparison of different crowdsourcing platforms

After researching these platforms, the author found some differences between these platforms. The differences between the approaches to these platforms are as follows (Table 4).

Table 4: Comparison between TopCoder and Upwork

Key Factors	TopCoder	Upwork
Basis of the platform	TopCoder is a platform where they are hosting competition for the project.	Upwork is a platform where clients can deal with a project with a crowd of talents.
Project ideas	The clients propose the project idea to TopCoder before hosting the competition	The clients propose and post the project idea directly to the Upwork website.
Dealing with the crowd	TopCoder is dealing with the project with the crowd for the solution.	Clients are dealing with the talents for the solution.
Test case preparation	TopCoder determines the test case preparation.	The candidate determines the test case preparation.
Finding bug	TopCoder hosts a competition for finding and fixing the bugs.	Candidates are responsible for fixing the bugs.
Product run and evaluation	A review board run the product and evaluates all the submissions.	Clients are responsible for a test run and check the product.
Crowd participants	Participants compete with each other to win the competition by getting a good score in every submission.	Talents compete among themselves through bidding the project with a low rate and short delivery time to get the project.
Development process	During the coding, it is important to follow the process and generate the documents.	During the development, they can follow their own steps with minor concerns and documentation.
Quality assurance of the product	TopCoder ensures product quality and timely delivery.	Upwork does not ensure the quality and delivery of the product.
Scammers	TopCoder is a scamming free platform.	Upwork has a lot of complaints regarding scamming.
Project rate	The project rate depends on the project type and performance.	The project rate depends on the agreement of the clients and candidates.
Platform charge	TopCoder usually charges 20% of the prize amount as an admin fee from clients and they do not charge from participates (TopCoder. Contest pricing., 2020).	Upwork charges 3% of the payment for the clients. At the same time, they charge 20% for the first \$500 bill, 10% for the payment between \$500.01 to \$10,000 and 5% for the exceed \$10,000 for the candidates respectively (Upwork, pricing, 2020).

5. Findings and Discussion

Both platforms are successful in utilizing distinct business models and catering their offerings as software development outsourcing services. Although there are significant differences in outsourcing methods, processes and tools between these platforms. Both the companies are following innovative methods and tapping into the network of developers for software development as evidence such as TopCoder has already 63,167 completed challenge and rewards \$104,476,517.57 total prize (TopCoder statistics, 2020). Upwork has 5 million+ of registered trusted business companies (Upwork, 2020). Software development companies can adopt any of these platforms for software development. Both platforms are providing the best service to their clients. Upwork has 5 million registered clients (Green, 2018) and TopCoder has more than 400,000 members from 190+ countries (TopCoder, 2020), which means it is free from doubt that both platforms have large satisfied community members. The implementation of their approach to software development with a specific time frame is very unique. Adopting crowdsourcing helps companies to develop software more than traditional development. Sometimes companies cannot find the proper solution due to the limited number of members in an organization but through this crowdsourcing method the organizations can solve any serious problem they may face. Many organizations find unsolvable solutions, saving money and time to use those platforms.

TopCoder claims that it has reduced cost savings by 30-80% using crowdsourcing (TopCoder, 2020). Traditional software development requires companies to have designers, developers, software testers and many members to develop software, where through these crowdsourcing platforms companies only provide their product specification, requirements and get the product they want. They do not need to worry about phases of development, so it can be agreed that crowdsourcing has a great impact on software development. Both companies have made great changes for talents because previously it was very difficult to prove their talents as jobs are limited. Now, talents can choose the work that suits them and can work from anywhere in the world. Both companies have good strengths to overcome their weaknesses to create great opportunities for clients and talents.

5.1 TopCoder

After reviewing the business models and processes of both organizations, the authors found that TopCoder is being used by outsourcing companies to host software development competitions

in the community of developers of the TopCoder ecosystem. The significant difference in software development tasks in these platforms is that the TopCoder determines the phases of the entire project in the software development cycle whereas participants and the clients determine the phases of the entire project in Upwork. TopCoder splits a given client project into many smaller parts and then hosts multiple competitions in the community for these tasks and picks the best result among the submissions. The charges on these platforms are quite different, as TopCoder charges only from clients where Upwork charges from both the clients and participants.

Both of the company's approaches for software development are unique in the crowdsourcing software development landscape as they have designed a great model for reducing cost for development, ideation to product development and thus reducing the time for go-to-market with the product. The software development cycle is very concise, comprehensive, iterative and robust in the TopCoder platform. They break down the software development cycle from product ideation to deployment into many smaller parts. They also host a competition for software bugs checking and fixing to maintain the product quality. TopCoder crowdsourcing models allows flexible software development where companies are free to choose the software development phase for realizing their project. Crowdsourcing and robust review processes ensure the best product quality, fast delivery, security and on time and budget to deliver the best software development that allows companies to focus on more strategic planning activities.

TopCoder's innovative hierarchical based software development through crowdsourcing systems for the clients includes many review processes, project management, a community forum for participation collaboration. TopCoder model ensures 2-5 months faster delivery time with 250% less critical bugs (TopCoder Solution, 2020). Most of the companies are satisfied with their services to solve new problems or develop a product. One such example of a client is the U.S. Navy used the TopCoder platform to crowdsource the development of the dashboard visualization, which is delivered within just 72 hours (TopCoder Solution, 2020).

Recommendation: Although TopCoder's contribution to software development is great, some improvement is needed in creating a review board to review all submissions from participants. A member name “*billsedison*” has raised a problem in the slack channel that “*Suppose a member is eligible as both competitor and reviewer, he joined a series of challenges as a competitor. But in some other challenges of this series, he played the role of a reviewer. It seems to be a common case, but do you think it is acceptable or fair?*” (Kondov, 2017).

So, if they hire someone from the review board who is competing for a different task on different challenges in the same series, it could put a bad impact on their review board. Therefore, in order to be fair enough for all participants in the process of reviewing submitted solutions, they need to improve in this area.

5.2 Upwork

Upwork serves as a middle platform where direct collaboration takes place between clients and participants to solve the development task. At Upwork, clients are free to choose suitable candidates among a pool of thousands to collaborate on the whole or parts of the project. Similarly, freelance developers are also free to choose the projects of their choice. A great aspect of Upwork is that there is an option for hourly and project-based fees so that clients can deal a small project with hourly fees and candidates can worth their every minute for spending on development wherein TopCoder, only reward the best solution providers.

The steps of software development through this platform are very flexible, as the organization or participants can set the stages of software development of their choice. The Upwork model does not include a review board, the clients themselves are responsible to check the submission quality and oversee the project development activities and progress of the project. Clients can accept the project or ask participants for updates. Many of the organizations have benefited from this platform. It is impressive that the author has seen 2 million + client reviews with an overall 4.9 stars out of 5 stars in Upwork (Upwork review, 2020). Hence, it is clear that most of the clients and organizations are satisfied through this platform. An appropriate example is the CEO and co-founder of Instapage said that “*instapage saved \$2.3 million with Upwork. Upwork took a lot of stress off of growing with minimal resources*” (Upwork, 2020).

Recommendation: Upwork needs to be aware of the scammers who are cheating with people on this platform. It is really important to be aware of the scammers on this platform because any organization or participants may lose their credibility to be scammed from this platform. There are some complaints from both clients and participants regarding scams on this platform. A way of Upwork needs to be developed to ensure that no one gets scammed through this platform. Hence, they need to improve customer service and build a team to remove scams from the platform and actively assist users in an unforeseen situation.

6. Conclusion

The main aim of this thesis was to investigate the process of crowdsourcing approaches to software development and make comparisons between the platforms named Topcoder and Upwork.

Four different forms of crowdsourcing and the possible benefits have been explained in the literature review section. Also, detailed information about the software development cycle, phases in crowdsourcing were investigated. Besides, the adoption process used by companies were examined respectively.

In the practical part, the comparisons among the current business models and the distinct approaches between the platforms (Topcoder and Upwork) for software development was described. The SWOT analysis of the current study has explored the disadvantages of both platforms.

Companies that have already adopted crowdsourcing as a part of their software development process were able to achieve significant benefits such as cost reduction, faster delivery and product safety. Both the crowdsourcing platforms were found beneficial for companies and at the same time, it showed that outsourcers could meet their needs. Approaches for software development provided great opportunities for new developers to use their talent in the software development industry.

The proposed recommendation of this study revealed that the adoption of these innovative methods of crowdsourcing software development of both the platforms can be used as important tools to improve the delicacy of the companies to find solutions and fulfill their needs.

7. Bibliography

- CrowdWisdom360. [online]. Available from: <https://www.crowdwisdom360.com/>. Accessed 17 November 2020.
- Fournier, A. *6 Great Advantages of Crowdsourcing you can Benefit From*. [online]. 2019 Available from: <https://www.braineet.com/blog/crowdsourcing-benefits/#:~:text=In%20this%20post%2C%20we'll,Reduced%20management%20burden>. Accessed 20 November 2020.
- Green, D. D., Walker, C., Alabulththim, A., Smith, D., Phillips, M. *Fueling the Gig Economy: A Case Study Evaluation of Upwork.com*. Management and Economics Research Journal, 2018. DOI: 10.18639/MERJ.2018.04.523634.
- Hammon, L., Hippner, H. *Crowdsourcing*. *Bus Inf Syst Eng*. 4, 2012 DOI: 10.1007/s12599-012-0215-7.
- Hasteer, N., Nazir, N., Bansal, A. and Murthy, B.K. *Crowdsourcing Software Development: Many Benefits Many Concerns*. 2016. DOI: 10.1016/j.procs.2016.02.009.
- Howe, J. *Crowdsourcing: a definition* [online]. 2006. Available from: https://crowdsourcing.typepad.com/cs/2006/06/crowdsourcing_a.html. Accessed 28 November 2020.
- Huhns, M.N., Wu, W. and Tsai, W.-T. *Cloud-Based Software Crowdsourcing*. 2013. DOI: 10.1109/MIC.2014.46.
- IBM. *Software development*. [online]. Available from: <https://www.ibm.com/topics/software-development>. Accessed 31 October 2020.
- Kondov, S.V. *Crowdsourcing software development problems experienced from the developer's perspective* (Master Thesis). Supervisor: John Stouby Persson, PhD Associate Professor. Aalborg University. September 26th, 2017. Available from: https://projekter.aau.dk/projekter/files/263510469/Svilen.Kondov_IDA10_Master.Thesis_Crowdsourcing.pdf.
- Lacity, M. C. and Hirschheim, R. *The information systems outsourcing bandwagon*. Sloan Management Review, 35(1), 73–86, 1993. Available from: <https://sloanreview.mit.edu/article/the-information-systems-outsourcing-bandwagon/>.
- Lakhani, K. R., Garvin, D.A., Lonstein, E. *TopCoder (A): Developing software through crowdsourcing*. HBS Case 610-032, Harvard Business School, Boston, 2010. Available from: <https://hbsp.harvard.edu/product/610032-PDF-ENG>.
- Latoza, T.D., Hoek A.V.D. *Crowdsourcing in Software Engineering: Models, Motivations, and Challenges*. pp. 74-80, vol. 33, 2016. DOI: 10.1109/MS.2016.12.
- Lebraty, J. F., Katia, L. L. *Forms of Crowdsourcing*. 2013. DOI: 10.1002/9781118760765.ch4.

- Leicht, N, Durward, D, Blohm, I, Leimeister, JM. *Crowdsourcing in Software Development: A State-of-the-Art Analysis*. In Proceedings of the 28th BledeConference (ISD'15), 2015. Available from: https://www.alexandria.unisg.ch/243336/1/JML_497.pdf.
- Li, W., Tsai, W.-T., Wu, W. *Crowdsourcing for Large-Scale Software Development*. 2015. DOI: 10.1007/978-3-662-47011-4_1.
- Love, D. *Introduction AppStori, The App promotion platform developers need to know about*. [online]. 2012. Available from: <https://www.bizandtech.net/introducing-appstori-app-promotion-platform-developers-need-know-about>. Accessed 18 December 2020.
- Lunden, I. *Elance-oDesk Rebrands as Upwork, Debuts Slack-Like Chat Platform*. [online]. 2015. Available from: <https://techcrunch.com/2015/05/05/elance-odesk-rebrands-as-upwork-debuts-slack-like-chat-platform/>. Accessed 11 November 2020.
- Mao, K., Capra, L., Harman, M. and Jia, Y. *A survey of the use of Crowdsourcing in Software Engineering*. *Journal of Systems and Software* 126, 2015. DOI: 10.1016/j.jss.2016.09.015.
- Qin, S., Van Der Velde, D., Chatzakis, E. *Exploring barriers and opportunities in adopting crowdsourcing based new product development in manufacturing SMEs*. *Chin. J. Mech. Eng.* 29, 1052–1066, 2016. <https://doi.org/10.3901/CJME.2016.0808.089>.
- Saxton, Gregory D. and Oh, Onook and Kishore, Rajiv. *Rules of Crowdsourcing: Models, Issues, and Systems of Control*. *Information Systems Management*, vol. 30, pp. 2-20, 2013. Available at SSRN: <https://ssrn.com/abstract=2187999>.
- Schach, S.R. *Software Engineering*. 7th edition Mc Graw Hill Education, 2007. Available at: <https://www.amazon.com/Object-Oriented-Classical-Software-Engineering-Stephen/dp/0073376183>.
- Sherief, N., Jiang, N., Hosseini, M., Phalp, K. and Ali, R. *Crowdsourcing software evaluation*. 2014. DOI: 10.1145/2601248.2601300.
- Stol, K. J., Cagalayan, B., Fitzgerald, B. *Competition-Based Crowdsourcing Software Development: A Multi-Method study from a customer perspective*. Volume: 45, Issue: 3, 2020. DOI: 10.1109/TSE.2017.2774297.
- TopCoder. *Community*. [online]. Available from: <https://www.topcoder.com/company/community/>. Accessed 06 November 2020.
- TopCoder. *Solution*. [online]. Available from: <https://www.topcoder.com/solutions/>. Accessed 08 November 2020.
- TopCoder. *Statistics*. [online]. Available from: [https://www.topcoder.com/community/statistics?tracks \[All-pills\] =0](https://www.topcoder.com/community/statistics?tracks [All-pills] =0). Accessed 14 November 2020.
- TopCoder. *A platform for innovation overview*. [online]. Available from: https://www.nasa.gov/sites/default/files/651447main_TopCoder_Mike_D1_830am.pdf. Accessed 23 October 2020.

- TopCoder. *Contest pricing*. [online]. Available from: <https://www.topcoder.com/html/cockpit/framework/content/pricing.html>. Accessed 18 December 2020.
- Upwork. *How it works*. [online]. Available from: <https://www.upwork.com/i/how-it-works/freelancer/>. Accessed 11 November 2020.
- Upwork. [online]. Available from: <https://www.upwork.com/>. Accessed 11 November 2020
- Upwork. *Pricing*. [online]. Available from: <https://www.upwork.com/i/pricing/>. Accessed 14 November 2020.
- Upwork. *Reviews*. [online]. Available from: <https://www.upwork.com/reviews/?rating=1%3A2>. Accessed 14 November 2020.
- Usui, Y., Morisaki, S. *An Approach for Crowdsourcing Software Development* [online]. 2016. Available from: https://www.researchgate.net/publication/267782479_An_Approach_for_Crowdsourcing_Software_Development. Accessed 16 October 2020.
- uTest. [online]. Available from: [uTest.com](https://www.utest.com). Accessed 25 October 2020.
- Weber, L. *Marketing to the Social Web*. 2nd ed. The United States: John Wiley & Sons, Inc, 2009. Available at: <https://www.wiley.com/en-us/Marketing+to+the+Social+Web%3A+How+Digital+Customer+Communities+Build+Your+Business%2C+2nd+Edition-p-9780470410974.b>. Accessed 14 September 2020.
- White, J. *What is Crowdsourcing and How Does It Work? Definition and Example – TheStreet* [online]. 2019. Available from: <https://www.thestreet.com/personal-finance/education/what-is-crowdsourcing-15026002#:~:text=Crowdsourcing%20allows%20businesses%20to%20perform,efficient%20way%20to%20do%20work>. Accessed 18 October 2020.
- Whitla, P. *Crowdsourcing and its Application in Marketing Activities*. Contemporary Management Research, 2009. DOI: 10.7903/cmr.1145.
- Wu, W., Tsai, W. T., Li, W. *Creative software crowdsourcing: From components and algorithm development to project concept formations*. Int. J. Creative Computing 1(1):57 – 91, 2013. DOI: 10.1504/IJCRC.2013.056925.