Crowdsourced Testing Services for Mobile apps

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Abstract— Recent publications have pointed out a number of challenges and challenges for when engineers validate mobile apps using a conventional way inside a testing laboratory. Top two issues include: a) higher test costs due to the diversity of mobile devices and platforms; b) difficulty in conducting large-sale user-oriented performance and usability testing. A new testing approach, known as crowdsourced testing, provides a promising way to address these challenges and issues. This paper provides a comprehensive tutorial on crowdsourced test services, and informative concepts, insights, and detailed discussion about common questions raised by engineers and managers. It presents a clear comparative view between mobile crowdsourced testing with traditional lab-based mobile testing. In addition, it also summarizes and compares different major players, their commercial products, and solutions in mobile crowdsourced test services. Furthermore, it examines the major issues, challenges, and needs.

Keywords—Mobile testing, crowdsourced testing, crowdsourcing, test tool, tester

I. INTRODUCTION

With the increasing popularity of smart phones and mobile devices, mobile application (app) markets have been growing rapidly. According to the recent Dazeinfo's market report, mobile apps will have more than 268 billion downloads and reach to $77 billion worth of revenue by the end of 2017 (www.dazeinfo.com). With the fast increase of the number of developed mobile apps, mobile device vendors and types, platforms, and appliances, we need novel cost-effective test approaches and tools to ensure quality of mobile apps.

Crowdsourced testing uses an online platform to assign software test tasks to a group of online testers. Recently, it has become an emerging software testing approach, and has gained its popularity in software engineering community [1]. Today, crowdsourced testing has been used to validate mobile apps using wireless internet with participants from all over the world to provide on-demand testing for mobile apps in real-word environment [2]. However, there are many open questions relating to this subject because there are few published papers discussing its essential concepts and addressing the related issues and challenges. This article aims to provide an informative discussion and tutorial on crowdsourced test services for mobile apps, including basic concepts, infrastructures, major players and platforms, issues and challenges.

II. MOBILE CROWDSOURCED TESTING

A. What is Mobile Crowdsourced Testing?

Crowdsourced testing refers to outsourced software testing tasks to a group of freelance real testers, who help to validate software under real world user conditions. Assuring software quality in this approach allows companies to gather real insight and feedback, and to identify defects quickly and cheaply [3].

We use mobile crowdsourced testing to refer to "testing activities for mobile apps (both native apps and mobile web apps) using freelance testers as users in a community on diverse wireless connectivity infrastructures to ensure the quality of mobile apps in functions, behaviors, performance, and quality of service, as well as mobile app special features, such as mobility, usability, security and compatibility."

There are three types of participants in a mobile crowdsourced testing community. They are: a) crowdsourced mobile testers, b) crowdsourced testing community venders, and c) crowdsourced test customers. Crowdsourced mobile testers refer to diverse mobile users, who like to work as freelance mobile testers for selected mobile app testing projects and tasks using their own mobile devices in pre-configured real-world wireless network infrastructures. A crowdsourced testing community vender refers to a service vendor who provides a mobile and online testing community based on provided mobile networking infrastructures, and provide diverse mobile app testing services for project managers, crowdsourced mobile testers, and test customers. Crowdsourced test customers are mobile app vendors or owners. They hire freelance mobile testers to complete their published mobile app testing tasks and projects, and provides them with incentives and payments based on their services.

B. Why is Mobile Crowdsourced Testing Important?

There are a number of challenges and issues in mobile app testing [4]. First, there are a thousand kinds of mobile devices and various mobile platforms on markets. This leads to a higher testing cost from using real mobile devices and testers. Second, mobile apps are commonly supported by different

wireless connectivity infrastructures and service plans. Hence, mobile testers need to validate mobile apps' functions, features and capabilities using diverse wireless or/and wireless internet connectivity. This requires mobile networking service costs and infrastructure support in a lab-based testing environment. Finally, mobility of mobile apps provides location-based services, which need to be tested in diverse real user environments on different geographical locations with different languages.

Although mobile crowdsourced testing has to face some challenges and limitations, such as unit, integration and stress testing, we think mobile crowdsourced testing may be a complement to traditional laboratory testing for handling above issues [5]. Table I presents a comparison between lab-based mobile testing and mobile crowdsourced testing.

TABLE I. MOBILE CROWDSOURCED TESTING VS LAB-BASED MOBILE TESTING

Features	Mobile Crowdsourced Testing	Lab-Based Mobile Testing
Test cost	Lower testing costs due to freelance testers and their devices.	Higher testing costs due to the usage of diverse mobile devices, set-up wireless networks, as well as contracted testers;
Testing quality	Ad-hoc testing quality control and coverage criteria	In-house testing quality control based on pre-defined test coverage criteria and QA standards
Scalability	Ad-hoc scalability testing based on the number of engaged freelanced testers	A limited testing scale, restricted by test resources in a testing laboratory
Tester	Freelance testers in a crowdsourced testing community	Internal contracted testers
Test process	Ad-hoc test processes	Controllable test process
Test results	Complicated to validate test results due to large number of reported bugs from freelance testers	Easy to validate test results based on in-house bug reviews
Device-based testing	Using crowdsourced mobile tester's devices	Using test devices in a test laboratory
Simulation-based testing	Current crowdsourcing testing platforms usually do not support simulation testing	Emulation-based and simulation-based testing performed in a testing laboratory
Test automation	Limited test tools available to freelance testers	Selected test tools are available to in-house testers
Function and GUI testing	By crowdsourced mobile testers	By contract test engineers
Usability testing	In a real-world user environment	In laboratory test environment
Compatibility testing	Easily performed based on the diversity of mobile devices used by freelanced testers	Limited to the available devices in a testing laboratory
Location & mobility testing	Easily performed based on diverse locations of freelanced testers	Very difficult to perform location-based testing in a laboratory

According to Table 1, mobile crowdsourced testing has several advantages and benefits, which are listed as follows.

Lower costs – Due to the usage of mobile devices of freelance testers, mobile crowdsourced testing reduces the costs of mobile devices as well as wireless connectivity service charges.

User-oriented testing environments–In mobile crowdsourced testing, mobile apps are tested in a real-world user environment. This provides a better validation environment for testers to discover the problems in mobile apps relating to user devices, location and mobility, usability, and nationalization.

Testing at large-scale –Mobile apps could be tested concurrently by crowdsourced testers at a large-scale if many testers are available testing in a crowdsourced testing community.

Concurrent testing – When a project has enough freelance testers, a mobile app could be easily validated concurrently on different mobile device environment platforms, and connectivity infrastructures.

Scarce test expects–Crowdsourced test customers can hire top test experts in a mobile crowdsourced testing community, such as security specialists or usability specialists.

In recent years, crowdsourcing software engineer has become a new research hotspot [6]. Many companies and institutes are actively conducting research projects in this area. Figure 1 shows a word cloud with all key words from the 96 articles about crowdsourcing software engineer denoting the popularity of the topics covered. As we can see in this bird's eye view, crowdsourced testing has become one of the most popular topics.

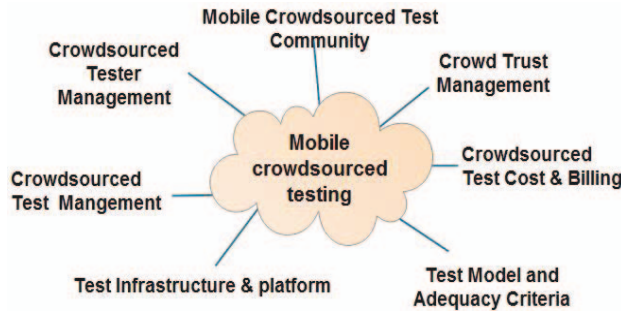Fig. 1. Popularity of topics about crowdsourcing software engineer

Fig. 2. The scope of crowdsourced testing for mobile app

C. Focuses and Scope

Mobile crowdsourced testing is a kind of field test. It has some distinct advantages on validating mobile apps in the following areas.

- *Mobile compatibility testing*, in which mobile apps are validated on crowdsourced testers' diverse mobile devices and platforms.
- *Mobile usability testing,* in which mobile apps are tested by executing various user-centered operation scenarios in diverse environmental contexts.
- *Location-based mobility testing*, in which mobility service functions are easily tested via mobile testers in different geographical locations.
- *Mobile function testing,* in which mobile apps are executed by crowdsourced mobile testers to evaluate diverse user operation services and functions scenarios.
- *Mobile security and privacy testing, in* which mobile apps could be evaluated and checked by security professionals hired on crowdsourced testing community.

As shown in Figure 2, the scope of crowdsourced testing for mobile apps provide the following eight features and services.

Mobile crowdsourced testing community refers to network communities, in which crowdsourced mobile testers share knowledge, skills, and experiences about mobile testing.

Crowdsourced tester management refers to activities that manage crowdsourced mobile testers, including tester register, tester education, tester evaluation, and tester certification.

Crowdsourced test customer management refers to activities that manage crowdsourced test customers, including customer register, customer certification, etc.

Crowd trust management refers to activities that identify dishonest test behaviors and results, and evaluate trust worthiness of crowdsourced mobile testers.

Crowdsourced test management refers to activities that manage crowdsourced test tasks on mobile apps, including test task publication, application, and allocation, and test result confirmation.

Crowdsourced test cost and billing refers to a business cost and service model, in which crowdsourced mobile testers will be paid based on their quality of testing services. On the other hand, crowdsourced test customers will be charged for their used crowdsourced mobile testers and system resources, for example, computer and storage server machines and network usage as well as test automation support services.

Test model and adequacy criteria refers to activities that model key factors and features of mobile apps, as well as analyze and evaluate crowdsourced test quality.

Test infrastructure and platform refers to study of solutions on how to build the infrastructures and platforms for mobile crowdsourced testing.

III. INFRASTRUCTURE OF CROWDSOURCED TEST SERVICES

Today, a number of mobile crowdsourced testing services and platforms have been developed. Typical examples include Usertesting, uTest, and TestCloud. These crowdsourced testing platforms provide a cloud-based infrastructure to connect mobile app developers with thousands of crowdsourced mobile testers. However, the existing test infrastructures only provide community and project management services, but lack services in test automation, testing resource and infrastructure management. Figure 3 presents a next-generation cloud-based infrastructure for mobile crowdsourced testing.

Mobile app servers communicate with mobile apps on mobile devices through wireless networks, and provide information and services for mobile apps. Crowdsourced testing platforms provide test device resources, tools, and management and test services to support mobile testing remotely by crowdsourced mobile testers through Internet.
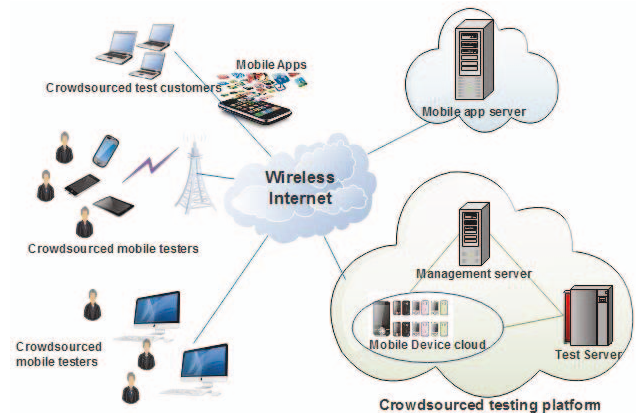

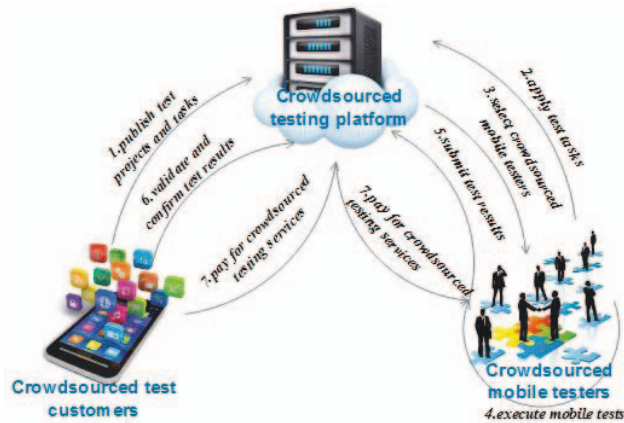Fig. 3. Next-generation crowdsourced testing infrastructure

Fig. 4. Test process for mobile crowdsourced testing

Based on our engineering experience and observations, a test process for mobile crowdsourced testing is proposed and presented in Figure 4.

Step 1 - Publish test projects and tasks
- Crowdsourced test customers submit under-test mobile apps to a crowdsourced testing platform. Then, they set a testing project and its test requirements as well as expected testing criteria.

Step 2 - Apply crowdsourced testing tasks
- Crowdsourced mobile testers apply to the posted projects and testing tasks.

Step 3 - Select crowdsourced mobile testers

- A test project manager using a crowdsourced testing platform to select appropriate mobile testers from applicants for a given project according to the test requirements, test criteria, and testers' profiles.

Step 4 - Execute mobile tests
- Crowdsourced testers execute test tasks (test cases or/and test scripts) on mobile devices using real wireless networking environments.

Step 5 - Submit test results
- Crowdsourced mobile testers submit test results and report the faults that they found.

Step 6 – Validate and confirm test results
- Testing project customers analyze and confirm test results submitted by crowdsourced mobile testers, and then evaluate test quality.

Step 7- Payments and incentives
- Project customers make payments or provide incentives to crowdsourced mobile testers using a billing service in a crowdsourced testing platforms.

IV. MAJOR PLAYERS

In recent years, some popular mobile crowdsourced testing services and platforms have attracted lots of mobile app developers and testers. Table II listed a number of major players in mobile crowdsourced testing and their provided services and platforms, as well as our comparative analysis based on experience and observations.

TABLE I. CROWDSOURCED TESTING PLATFORMS FOR MOBILE APPS

Features		Usertesting (usertesting.com)	99Test (99tests.com)	Testcloud (test-cloud.io)	UberTesters (ubertesters.com)	Utest (utest.com)	Testin (testin.cn)	Baidu MTC (mtc.baidu.com)	Sobug (sobug.com)
Number of testers		Unknown	20,000	14,000	Unknown	200,000	150,000	Unknown	8,000
Charge customer		√	√	√	√	×	√	×	√
Pay for tester	By new found bugs	×	√	√	×	√	√	√	√
	By finished test tasks or spend time	√	×	√	√	×	×	×	×
Tester education		√	×	√	√	√	√	x	√
Tester certification		√	×	√	√	√	√	x	√
Testing for mobile Web apps		√	√	√	√	√	√	√	√
Testing for mobile native apps		√	√	√	√	√	√	√	√
Android		√	√	√	√	√	√	√	√
IOS		√	√	√	√	√	√	√	√
Function testing		×	√	√	√	√	√	×	×
Usability testing		√	√	√	√	√	√	√	×
Compatibility testing		×	√	√	×	√	√	√	×
Load & Performance testing		×	√	×	×	√	×	×	×

Location & Mobility testing	×	×	×	√	√	×	×	×
Security & privacy testing	×	√	√	×	√	×	×	√
Test requirement definition	√	√	√	√	√	√	√	√
Recommend tester	√	√	×	×	×	√	√	×
Test bug confirm	By customer	×	√	√	×	√	√	√	√
	By platform	√	×	×	√	×	×	×	×
Test context collection	√	×	√	√	×	√	×	×
Test tools or SDK	√	×	√	√	×	×	×	×

A. Crowdsourcing community services

Although some of players (i.e. Testin) listed thousands of crowdsourced mobile testers, many of their testers are not active. In most crowdsourced testing platforms, customers have to select mobile testers with limited information. Only a few of platforms provide certain tester recommendation function service for customers. To help customers to find qualified crowdsourced mobile testers, some players provide online mobile testing courses to train crowdsourced mobile testers and certify them with certification exams. To provide incentive to testers, most of these players charge their customers according to the number of hired testers, and pay them based on the number of detected new bugs or their completed tasks.

B. Testing platforms and testing services

All listed players support both online web app testing and native mobile apps testing on Android and IOS platforms. Some of them provide different types of testing services, including function testing, usability testing, location testing, load testing, and security testing.

C. Testing requirements and quality validation

All mobile crowdsourced testing platforms (such as Testcloud, UberTesters, and Utest) in Table II allow customers to set testing requirements and criteria, and to define required test device contexts. Most crowdsourced testing platforms directly transfer reported bugs from testers to customers, and then customers have to manually confirm validity of bugs. Obviously bug confirming is time consuming and tedious.

D. Testing automation

Most current mobile crowdsourced testing platforms only can be considered as a testing environment with a limited test automation support since they are lack adequate automatic test tools. For example, Usertesting provides a screen record tool to record screen videos for usability testing. Testcloud and UberTesters provide some test tools and SDKs to collect device contexts, server logs and operation tracks for mobile testing.

V. ISSUES, NEEDS, AND CHALLENGES

Although crowdsourced testing becomes a popular trend in mobile application testing, people have encountered numerous issues and challenges.

A. Test quality evaluation

Thomas LaToza in [8] has pointed that quality assurance is a fundamental challenge in crowdsourcing software engineering. According to the feedback of crowdsourced testing practitioners, the quality of mobile crowdsourced testing is unstable and uncontrollable due to the following two reasons. The *first* is the diversity of online-recruited testers with different levels of project commitment, experience, and skills, and different project schedules, management processes, and provided incentives. The *second* is the lack of well-defined techniques and tools to assist test adequacy evaluation for testing project managers and testers. Hence, this major issue brings the following challenges and needs in test quality evaluation.

- How to control and evaluate testing quality and coverage for mobile apps in a crowdsourced testing process? To address this challenge, we need more practical research results that provide testers with user-centered mobile app test models and test adequacy evaluation techniques and standards. As more and more mobile apps (i.e. Waze, and tripadvisor) are developed to provide users with mobility features and location-based services, there is more of a need in crowdsourced testing quality evaluation such as developing innovative mobile test models [9], user-oriented test adequacy [10], and test coverage analysis techniques [11]. We expect these research results providing fundamental theoretic base for test automation in a crowdsourced testing process.

- How to evaluate the reported bugs from testers and their testing quality in a project? Evaluating reported bugs from testers and their quality is a time-consuming task where many crowdsourced testers are involved for a mobile test project where diverse mobile platforms and languages are supported by given mobile app. This suggests that there is a need to develop automatic (or semi-automatic) data-driven techniques to support bug evaluation and quality evaluation for each tester.

B. Crowdsourced testing community

A mobile enabled online testing community needs to provide diverse services that support test project managers, free-lanced testers, mobile app test customers, and mobile app vendors in order to support crowd based testing. Providing an effective crowdsourced testing community for mobile apps must address several challenges and needs listed below.

- *How do we assist a test manager select good testers from a crowdsourced testing community?* Although the existing practitioners have provided project managers and mobile app clients with available tester information (i.e. profiles, skill certification, and resumes) to facilitate their tester selection, it is still not good enough to meet their expectations. With the advance of big data science and technology, people are looking forward to using data driven approaches and big data based ranking models to support tester selection based on the past project performance and test quality evaluation for each tester.

- *What are the cost-effective incentive models for testers and project managers?* It is a common to provide certain incentives to testers in a crowdsourced testing project. However, there is a lack of a comparative study on different incentive approaches and their effectiveness. Clearly, some data-driven methods and smart learning based techniques are needed to provide real-time intelligent incentive models and solutions.

C. Test automation

Test automation has been considered as an important and effective way to speed up a software test process and reduce the manual test operations. Although recent publications in [4][12] have discussed some test automation challenges and needs for mobile apps, crowdsourced testing brings certain unique mobile test automation challenges. Here are two typical ones.

- *How do we provide a seamless mobile test automation solution crossing diverse mobile devices for crowdsourced testers to support diverse mobile platforms?* In [4], authors examined different mobile test automation tools, and pointed out the real challenge in mobile app test automation is how to provide auto mobile test solutions supporting diverse mobile platforms and devices.

- *How do we provide a large-scale mobile test automation solution for testers in a crowdsourced testing environment and infrastructure?* In a crowdsourcing environment, it is difficult to find qualified testers with good mobile test automation skills. However, scalability testing for mobile applications required freelanced testers to understand and use easily operational test tools. This suggests that more automatic test solutions should be operated like usability test tools. Users don't need to know the details of operations.

VI. CONCLUSION AND FUTURE WORK

Crowdsourced test services for mobile apps has five major advantages. They are: a) testing could be done at anywhere and

anytime; b) cheaper testing costs; c) supporting on-demand mobile testing services in any language; d) supporting elastic scalable mobile testing operations; and e) freedom to fine and hire scarce test experts. As more and more mobile apps are constructed and deployed, crowdsourced testing becomes a hot topic in software testing community and interesting research subject for many researchers in the near future.

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