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Crowd sensing to monitor the waiting time of day-to-day services

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ABSTRACT
This work proposes the use of vivid impressions of users to monitor the waiting and service time in the provision of public and private services. The solution consists of an environment in which users can report the time spent waiting for the provision of a particular service. The waiting time for customer services is a problem that affects most cultures and has been studied by the academic community for several decades from the standpoint of psychology, sociology, marketing and computer science. In this paper we present a review of the literature on the subject, and also propose a classification of approaches that deal with this problem. We also report our participatory effort in articulating requirements and functionalities of a design solution to address this problem. A series of interviews were conducted with stakeholders and other people involved in the problem of waiting time delays in customer services, allowing requirements to be posed and validated through a survey. Finally, we present the latest details of an application being developed to address this problem and the final conclusions.

KEYWORDS
Mobile crowdsensing — Participatory sensing — Day-to-day services — Waiting time — Demorô.

1. Introduction

Regardless of cultures, people are usually involved in some way in the provision and consumption of services. These services can be provided by individuals or legal entities - and legal entities can be public or private organizations.

Given the wide diversity of models of service providers and agents, monitoring the waiting time for the service is quite difficult. In most cases, service providers are those who hold the best position to make that assessment, but do not have the interest to publish these metrics.

The resistance of providers to monitor the service time is a reflection of the poor quality in the agility of the services provided by these agents. The long wait to be attended in certain services has generated dissatisfaction in people who depend on them, and this widespread discontent of society generates demands for actions aimed at reducing the waiting time for day-to-day services.

One of the actions for fostering improvements in service delivery is the monitoring and publication of quality metrics. When the service time becomes known and public, the image of an organization is indeed affected in some way. If the service is good, it will benefit from advertising, but if this activity is of poor quality, certainly the company will be motivated to improve their service delivery.

This work proposes the use of vivid impressions of users for monitoring the service time in the provision of public and private services. The solution consists of an environment in which users can report the time spent waiting for the provision of a particular service. So the strategy can succeed, this account should be conducted through a simplified interface, preferably mobile, that takes advantage of the user's location information.

In a typical scenario, the user searches for queues registered in its surroundings for services he has an interest in. For each of these queues, the user can query the service time and contribute their experience in the respective service consumption. To provide better dialog with the user, a catalog should be built organized by keywords of the services that are subject to this type of monitoring, even though created in real time, automatically, on demand.

Services can be inferred from the crossing of information from company bases, locations (places) and skills for business areas. For example, it is possible to infer the services offered by banks, hospitals, shops, restaurants, subway stations, and so on. With this information, one can generate a map with the service time metrics and quality indicators with the latest information and consolidated historical data. This information is very attractive to users who, for example, are interested in finding out which is the nearest bank branch that has the lowest waiting times for provision.

The emergence of social and crowd computing is changing the landscape of research in CSCW. The strategy of leveraging crowds to solve non-trivial problems have been investigated in recent years by several research groups worldwide. However, as designers we lack practical experience in building these types of systems as well as dealing with issues, such as attracting and sustaining user participation [1].

In this context, the design of Demoro was carried out following the methodology of research through design, where speculative prototypes are constructed as a means of learning the best way to design these types of systems [2]. The prototypes are being built through participatory design, where end users actively participate in decisions affecting the project throughout its various stages.

The rest of the paper is organized as follows: Section II investigates the related work; Section III presents the methodology of design research utilized; Section IV describes the problem of monitoring the waiting time on customer services; Section V presents the proposed solution; Section VI describes the current prototype, and Section VII presents some discussion and conclusions.

2. Related work

The term crowdsourcing is closely related to the issues discussed in this work. Crowdsourcing has been broadly studied by various researchers, leading to the existence of different conceptualizations [3]. According to a popular definition, crowdsourcing refers to a distributed problem-solving model in which an undefined size crowd is engaged to solve a complex problem through an open call. The strategy of leveraging crowds to solve difficult or non-trivial problems has been investigated in recent years by several research groups, and our working group on Crowd Computing has published a number of research findings in the areas of strategic planning [4], requirements categorization [5], music crowdsourcing [6]–[8], citizen science [9], participatory sensing [10], [39], [40] and crowd-powered journalism [11], [42].

Furthermore, recent advancements in mobile phone technology spurred the birth of an exciting new paradigm for conducting sensing on a large scale, known in the literature as *participatory sensing* [12]–[14]. The key idea behind participatory sensing is to empower a crowd of ordinary citizens to collect and share sensed data from their surrounding environments using their mobile phones [15].

According to Kanhere [15], a typical application of participatory sensing operates on a centralized basis ie, sensor data collected by the phones of volunteers are reported (using wireless data communication) to a central server for processing and analysis. The sensing tasks on the phones can be triggered manually or automatically based on the current context. On the server, the data is analyzed and made available in various forms such as graphs or maps that show detection results of individual and / or community scale. The results can be displayed locally on mobile operators or accessed by the wider audience through portals, depending on the application's needs [15].

Smartphones can be considered multi-sensor equipment, since in a single appliance, one can find devices capable of providing real-time images, sounds, information about geolocation, inclination, and so on. Unlike traditional sensors, which generally require a process of data collection, smartphones have internet access, which ensures much more flexibility in obtaining this information.

As a result of these numerous features offered by smartphones, several applications that can leverage these multiple sensors to solve different problems in a socially distributed manner have been created. With the popularity of global positioning systems embedded in cell phones [16], [17], applications that are able to monitor traffic conditions through information provided by the crowd have emerged, such as *Waze* and *vTrack* [18].

Features of mobile phones can be explored with unusual applications. *Ear-Phone* [19] and *NoiseTube* [20] applications allow their users to monitor the noise level, obtained through a microphone, and to send that information to the application network. By using the information sent by various employees, it is possible to create a map with the classification of the noise level of numerous locations.

A very innovative idea is the *Pothole* application [21]. It is able to detect holes in a specific street through the combined use of global positioning system and cellular vibration detection by the accelerometer device. The *Sinalguru* application [22] monitors the stops at traffic lights and suggests its users the best speed to avoid red lights, and thus provides fewer stops and fuel economy for those who use it. Through particular characteristics of Wi-Fi receivers embedded in certain mobile devices, one can also determine the position with better precision in internal locations, as shown in the *Airplace* application [23].

2.1 Specific solutions to the waiting time problem

There are several studies dedicated to detect and monitor waiting time in various types of customer services. These approaches fall into two broad categories. The first category dedicated to solving this problem has an "infrastructural approach", meaning that some kind of action on the part of the property owners is needed for the deployment of a physical device or any software required. The second category consists of non-infrastructural initiatives. These initiatives generally use the customers' smartphones. Some of the non-infrastructural approaches do make opportunistic use of devices already installed on the properties, but as they do not require any intervention of local stakeholders, they are still considered to be non-infrastructural.

The first technology-based solution to address this problem was proposed by [24], who conceived, implemented and evaluated the use of time-stamped cards for waiting time monitoring. These cards were distributed to passengers in the airport when they joined the queue, and were returned at the end, and thereby it was possible to detect the behavior of waiting queues in the airport. The authors also experimented with solving this problem by using the images of the properties' surveillance cameras [25]. Although they are efficient, their deployment is difficult due to the high cost and the involved privacy issues.

Other types of sensors with lower costs have also been surveyed, such as infrared sensors [26], switching mats [27], Bluetooth [28] and Wi-Fi [29]. In all of these examples it is necessary to purchase equipment, or at least the installation of software on pre-existing devices in the property. All these initiatives end up not being very effective, except when the property has an interest or is required by law to monitor their customers' waiting time. The resistance of property owners in adopting initiatives to monitor the waiting time in lines has already been discussed in [30],[39], and is usually associated with negative publicity risk in case of high waiting times.

Assuming that the initiative for the solution of this problem will not be provided by the property owners, it is up to the society members to propose solutions to such problem. The main features of these initiatives is that they can be performed without any intervention or support from properties. The empowerment of society to solve this problem is done by means of crowdsensing initiatives through smartphones. At the time of writing this article we found four other research teams that make use of information collected from the crowd for identification, monitoring and prediction of waiting times in customer services.

The first work with this approach was the Lineking application [31], which presents a proposal capable of detecting the total waiting time at a diner through the orchestrated use of two components: the wireless sense and the location sense. The wireless sense detects user presence in the property through a warning issued by the operating system when a particular wifi network is available nearby the cell phone. On the other hand, the location sense, striving for energy efficiency, uses location information obtained from cell towers, wireless access points and GPS. The main contributions of this work are the proposition of mathematical models that can predict the waiting time (even under the condition of insufficient samples), and the energetically efficient mechanism of waiting detection.

The main limitation of this study lies in the fact that it was designed and evaluated in specific conditions of a site. For example, the removal of unwanted samples reported by users (the outliers) was made in a very simplistic form, based on observations specific to the cafeteria studied in the paper. The authors of this work then published an ongoing study [32] that instead of detecting the waiting time, dealt with detecting the length of queues. This mechanism benefits from information obtained from the mobile accelerometer, to classify the current state of the user within a state machine specified by the authors. Users' behavior in a queue is ranked in "standing", "walking at low speed" and "walking at normal speed". By analyzing the data reflecting the transition between these states, it is possible to detect how many times the user has moved forward in a queue, and the moment when he left it, so it is possible to estimate the amount of queue positions. A preliminary assessment showed that the accuracy of the mechanism is between 2-3 people in absolute error.

The work of [33] comprises three main components: recognition of the individual's activities, recognition of the queue's activities, and the partition of queues. The first component detects the user's current state, by reading the accelerometer, compass and Bluetooth of the ported smartphone. The component responsible for the recognition of queue patterns can detect the behavior of a particular queue. A queue's behavior is modeled on a basis formed by seven different attributes, and from this information, the third component is able to assign every single delay reported by users to a respective queue.

The fourth work analyzed in this paper is QueueVadis [34], a participatory sensing tool that firstly assists the user to identify individual waiting episodes in a queue. It then uses information reported from several users to separate them into different queues, and also to infer statistics and estimates about them. The proposal is able to provide useful estimates even when the percentage of participation in the system is 10%. The main contribution of this work is the proposal of a disambiguation system, which is able to identify people who are in the same queue through analysis of the trajectory that they run when moving forward in the line. The author argues that its mechanism may be embedded as a component in property applications, so that administrators are able to detect and somehow compensate users who have experienced high waiting times.

The work of Goncalves and colleagues [35] criticizes some alternatives for automatic detection of waiting times, and defends their proposal in which the users themselves report the amount of time spent waiting, as long as this is done with little effort. The authors describe an experiment in which interactive kiosks installed in four restaurants of an university campus, where people filled out their estimates of the time elapsed waiting up to the moment. This proposal is an example of a crowdsourcing initiative even in an infrastructuring paradigm.

At the time of writing this article, we searched Google Play and Apple Store for LineKing, QueueVadis and QueueSense applications, but they were not found. The unavailability of the aforementioned applications complicates their assessment by other researchers.

3. Research methodology

The emergence of social and crowd computing systems has been changing the landscape of research in CSCW and HCI (Human Computer Interaction). The success of systems like Wikipedia, Facebook, Digg, Amazon MTurk, Google Waze and others illustrates just some of the ways that this emerging technology can take, and the range of problems it can solve. The strategy of leveraging crowds to solve non-trivial problems has been investigated in recent years by several research groups worldwide.

However, designers lack practical experience to construct these types of systems as well as how to deal with issues such as attracting and retaining user participation [1]. In this context, the Demorô project was conducted under the perspective of research through design methodology, where speculative prototypes are constructed as a way of learning how to best design these kinds of systems [2]. In fact, our research followed the lines of the action design research (ADR) methodology, a combination of research through design and action research, characterized by a cyclical process in which construction, intervention and evaluation are strongly interconnected [36]. Thus, this project followed the main stages of ADR which are: 1) formulation of the problem; 2) construction, intervention and evaluation; 3) reflection and learning; and 4) formalization of learning. This approach allows us to create a technological artifact that can improve their efficiency through the various cycles of design and construction.

3.1 ADR in action: Demorô design

Like other case studies of ADR, the Demorô project has two parallel goals: to make an intervention in the participatory sensing applications' design space (to improve the experience of citizens attending day-to-day services) and to create theoretical knowledge by putting into practice and evaluating design principles used in the construction of the proposed application.

With regard to the problem formulation (first phase of ADR), Demorô's design was informed by a comprehensive review of the literature described in section II. In respect to the second phase of building, intervention and evaluation (BIE), the project adhered to the participatory design approach, which places the needs of end users in the forefront of the design, engaging them directly in the design decisions. In addition, we rely on the collaboration of students, teachers and researchers.

The third phase of the ADR - reflection and learning - was conducted through ongoing discussion and reflection on the effectiveness of the design decisions in addressing the problem (reflected in several features designed into the application), since at some point in the cyclical process of ADR we focused our efforts on a specific set of features to which we wanted to give greater focus. Finally, in the fourth and final phase of the methodology - the formalization of learning - we articulated a set of design recommendations that reflect the knowledge gained throughout the whole process.

4. The problem of monitoring the waiting time of customer services

This section aims to seek information that can assist in understanding the problem of waiting-time in customer services. It is not trivial to know in which areas lies the greater dissatisfaction due to the excessive waiting time for provision, but some research techniques can be used to get that answer. Techniques such as sentiment analysis in social networks posts and mining news can be very promising alternatives.

4.1 Opinion Poll

A major issue is to know in which areas users are more affected regarding the service time for the provision of services. A methodology to solve or mitigate this problem should take this information into account. To that end, it was carried out within the scope of this work a survey distributed via email and social networks. The interviewees answered the following question:

"What are the places or services that you face more queues or some kind of queuing to be serviced?"

The interviewees were asked to mark one to three options of a set of seven pre-defined categories. The alternatives were always shown in random order, which gave equal conditions for the selection of categories. The following options for each of the respondents were presented:

- Health care;
- The customer service center;
- Banking services;
- Public transportation services;
- Restaurants;
- Delivery services;
- other;

In all ninety-two respondents to the interview, as can be seen in Figure 1; 62% of people reported facing long wait time for calls related to health services, which is the most cited by the people, followed by customer service centers (57%), banks (55%), public transport stations (42%), restaurants (21%), delivery services (9%) and other (2%).

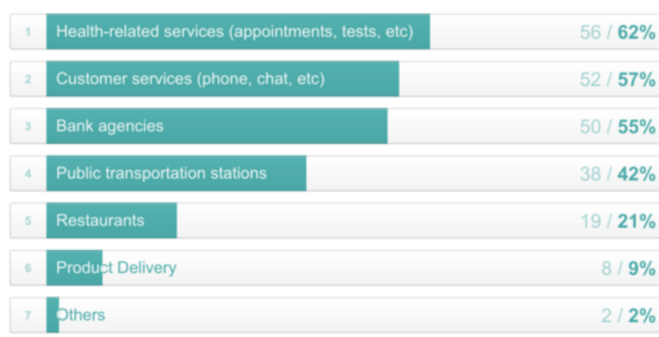

Figure 1. *Survey of categories with more frequent reported delays.*

When the option "Other" was selected, the user was immediately asked to specify this option. Two respondents made use of this functionality and reported facing waits at supermarkets. Health care refers to the services provided by hospitals, clinics and laboratories in appointments, tests, and so on. Customer care services are usually related to consumer call centers, such as those conducted by phone, email, chat and others.

Banking services are inherent to financial institutions, mainly banks, such as attendance at ATMs or traditional bank cashiers, as well as calls made to the bank's management department. For each of these services, there can be either wide competition queues while others dedicated to people with special needs, elderly or customer segments prioritized according to their banking score.

The category of public transportation services includes services related to mass transportation, such as bus, subway, rail, water or air. Typical examples of problems faced by users of these modals are waits at bus stops, metro stations, ferries and others. Air transportation users often face long waits for performing check-in procedures and baggage handling.

Restaurants are also a kind of place where users reported facing long service times, and these waits are often experienced in payment queues, early self service, waiter service, arrival of dishes (in a restaurant), or the request of invoice for payment of services.

In this research, we have collected some categories of likely places where reports of long waiting times can be sent through the crowd. However, there are still many other categories of places and *waiting* classifications not covered in this initial list. The solution proposed in this work considers as essential the ability to absorb new information from places and queues that are provided by the user.

4.2 Survey on consumer complaints websites

There are several websites that receive user complaints about products and services, like *Reclame Aqui, Reclamão, Denuncio, NuncaMais.net, Consumidor.Gov.Br* and *Procon SP*. Some of these websites are created by civil society and some others by government agencies, such as the Ministry of Justice and foundations of consumer protection.

In Brazil, the most popular of these sites is the *Reclame Aqui*, a website that allows searching complaints and companies through keywords. The site in question received 5 million complaints only in 2013 and has 320,000 hits a day, and of these, 20,000 for complaints, and 300,000 for reputed companies search.

While searching this portal for terms related to delay in service time, the following results were obtained. In search for the term "queue" we found 1750 results, and of these, 310 on a major fast food network, 274 of a retail network, 256 in a network of cinemas, 231 in a network of sporting goods stores, 227 in a bank, 224 at an amusement park and the others elsewhere.

By searching for the terms "delay" and "slowness", we found 30,627 and 17,562 results respectively. Most of these are related to delays in telemarketing call, order processing and delivery of products purchased in online shops. They are usually targeted at the companies responsible for the products, but some others are directed to carriers.

Complaints sites have a very important role in mediating consumers and service providers, and can be used to solve problems in a general way. However, this general approach is proven insufficient to deal with service time issues. These websites are not able to provide indicators for the average wait times for each of the services provided by companies.

Thus, the proposition of alternatives to solve this problem remains open. In this paper, we will specify a system that is capable of receiving information related to the wait time of day-to-day services. This system should be able to return quality metrics to the user towards the time needed to be serviced in real time, as well as historical data.

4.3 Interviews with potential actors

To better understand the issues involved in attending these types of services, interviews were conducted with particular users and employees of segments indicated in opinion poll. In each of these interviews, the following questions were posed: "Explain how your job works"; "What are the main reasons that cause delays and lengthy calls?" and "What are the cases where high standby time is justified?"

When interviewing a housewife and a public transport user, both reported that a problem commonly found associated with high wait times is the duplicity of function. In supermarkets the employees responsible for the checkout end up tasked to pack the goods as well, and in other cases, bus drivers are also responsible for cash handling. Two respondents reported that it would be very important that the application allows users to send suggestions to the property owners, so that they can improve their services (R1).

Another important story was obtained by an employee who has worked for eight years in the support department by phone. According to the interviewee, there are two main reasons that cause high wait times faced by customers of such service. The first one is related to the high number of calls in a short time, which is usually associated with some momentary outage. The second reason reported was the need that the attendant has, in some cases, to refer to higher levels of support complexity during a call. The interviewee noted that a better training of the first level of support could reduce the service time.

A very important finding that could be obtained through this conversation is that in many cases, even with a high service time, the user may be satisfied. This happens when he understands that his problem is complex and that it was possible to observe commitment and attention on the part of the attendant. To give the correct treatment to these cases, the respondent suggested that the application had a functionality that allows the user to make an assessment of his satisfaction associated with that service (R2).

A story that led to findings of great importance was obtained from a doctor who has experience in health care in public and private institutions. According to the respondent, the health emergency care is of extreme necessity, and when the wait is long, it can lead to the death of the attendee. This report shows that, especially in cases where patients wait for public hospital beds, transplants or transfers to specialized institutions, there are frequent occurrences of deaths while waiting for the provision of their needs.

This problem is not unique to the public system, as in the private health system many patients wait for weeks for prior authorization by health plans to carry out tests. According to the respondent, there are three main problems that lead to failures in health services. The first is the demand that is far above the capacity of health institutions. This problem is compounded by the lack of public information, which is the second reason mentioned by the interviewee. The lack of information leads people to seek help in the wrong places, for instance, going for emergency care units to investigate issues that could be resolved through consultation in a clinic or through a call to family health care. The third reason is the mismanagement that is present in most health institutions. The hospital management department is responsible, among other things, for implementing screening processes, deploying protocols that streamline and standardize medical care, investing in training their staff and deploying IT systems that facilitate access to information records, imaging studies and other resources.

The story above allowed us to raise two new requirements for the wait time monitoring system. The first one, suggested by the respondent, is to make available to the user, a list with descriptions of the services offered by the instituition (R3): this could prevent people to unnecessarily wait for services that are not offered by that institution. The interviewee also suggested that users could point out a second institution in his waiting report (R4), if particularly necessary, for example, when the hospital is beyond the health plan's responsibility and also needs to be mentioned in the report made by the user.

To enrich the requirements gathering, two other professionals were interviewed. One is a lawyer, who was chosen for the purpose of bringing relevant information related to consumer rights and service providers. The other is an expert in advertising, who could bring suggestions to boost the initiative.

The conversation with the expert in advertising was very fruitful. The specialist stressed the importance of these stories to be shared on social networks (R5), and also the use of gamification techniques, such as the creation of the figure of the mayor of a local (R6). The interviewee made a number of contributions to reinforce that all data collected on social networks should be truthful. Among them, she suggested that user profiles should be scanned (R7), and that reports should have their credibility verified by pressing a button "like/dislike"(R8).

To strengthen the interaction between people, the interviewee recommended the creation of micro-communities, where people could be notified of reports sent by users based on their areas of interest and geographical range (R9). Finally, the respondent recommended the creation of features that allow the use of this information for the monitoring of brands and also for conducting tasks of journalistic nature (R10). A good reference for this purpose is the detection of "trendings topics" of the application, capable of returning information on locations that are receiving a significant number of reports in a short time.

Soon after, an interview with a lawyer was conducted. The purpose of this discussion was to bring a legal standpoint, related to the rights and duties of consumers and managers of properties. However, during the conversation, it was also perceived a personal indignation on the part of the interviewee on the subject. The report showed that the lawyer is also facing issues concerning high wait time with public transport, in cafes and even in courts, while trying to get information about processes. The respondent reported that the long delay often occurs due to the lack of organization on the court, which means that employees have trouble finding a specific process. For this reason, waiting rooms are often overcrowded, further aggravating the waiting problem.

From a legal point of view, the lawyer said that there is no federal legislation on the subject. And that without this regulatory framework, property managers will never make this kind of monitoring, reinforcing the thesis proposed in [30], which advocates the responsibility of civil society itself to implement an initiative that deals with this problem. Some important requirements could be extracted from that conversation: the respondent suggested that the application could be a simplified way of disseminating consumer's rights, according to the place visited (R11), to assist citizens in a negotiation towards the fulfillment of their rights. Besides, the lawyer added that the property manager that received some waiting report must have the right to make replicas (R12).

It is possible that the property has no plausible justification for the problem, or even wants to provide some satisfaction to the consumer. Consumers should be able to make a retrospective report (R13). The respondent also suggested to display the percentage of reports that were answered by the property as a way to encourage the participation of establishments' managers on the platform, giving visibility to those who adopt good practices of dialogue with their clients, and using this information to determine the reputation of a property (R14). Finally, another suggestion given is that the user could be able to make a public complaint, or a private complaint to the property, in which only the two parties could have access to their content (R15). This last requirement was included because the respondent figured out situations in which consumers may not want to disclose their experience due to some social embarrassment.

Computer science experts have also been heard, including the authors of this paper. The following requirements could be gathered: data stored reports should be sufficient to produce statistics such as the minimum, maximum and average wait time (R16); the user should be able to select the location from a list of nearby locations (R17); the system should be able to infer existing lines through metadata available (R18); the user should be able to register properties and queues in the system (R19); the user must have access to all information related to his submitted reports (R20); the data produced by the application should be available in an open format accessible by other systems in machine-understandable languages (R21).

We also gathered requirements from the tools studied in the literature review. One of the most important requirements that could be taken from this phase was the automatic detection of waiting (R22), originally proposed in [31]. Another important requirement was the possibility of allowing the property owner to find, for example, customers who were waiting for longer than 10 minutes and applying some compensation policy (R23) such as amenities or discounts [34].

4.4 Requirements Evaluation

A survey was conducted in order to get confirmation from a wider group of people in regard to the requirements raised during

Table 1. *Requirements Evaluation Results*

Category	Requirement	Result
Information Access	- List with descriptions of the services offered by the property (R3)	essential
	- Sharing the report in social networks (R5)	necessary
	- Creating micro-communities where people can be notified of reports concerning areas of interest and geographical position (R9)	very important
	- Monitoring of brands, such as trending topics (R10)	necessary
	- Displaying consumer rights in a simplified format, according to the visited place (R11)	essential
	- Data reports should be sufficient to produce statistics such as average, maximum, and minimum wait time (R16)	essential
	- The user must have access to all the information related to his own submitted reports (R20)	essential
	- The data produced by the application should be available in an open format accessible by other systems in machine-understandable languages (R21)	necessary
Waiting time assessment	- Sending a suggestion for improvement in a waiting report (R1)	essential
	- Evaluate satisfaction with the waiting time with grades 1-5 (R2)	essential
Convenience	- Send a retroactive report (R13)	necessary
	- Select the location from a list of nearby locations (R17)	essential
	- Infer existing lines through property available metadata (R18)	essential
	- The user should be able to register new properties and lines in the system (R19)	essential
	- Automatic detection of waiting in a line (R22)	essential
Incentives	- Allowing the property manager to locate customers who faced delays to offer countervailing measures (R23)	essential
	- Create the figure of the property's mayor, a title given to the user that sent the biggest number of waiting reports related to the property (R6)	optional
	- Displaying the percentage of reports that were answered by the property as a way to encourage the participation of managers and owner of properties on the platform (R14)	essential
Data Integrity	- Profile verification during registration procedure to improve the accuracy of registration (R7)	essential
	- Creating buttons of "Like" and "Dislike" in the waiting report. If the user clicks on "Dislike", a dialog opens asking if the user wants to make a complaint (R8)	very important
Justice	- Allow the user to cite two or more institutions in a report (R4)	very important
	- Allow the manager of the property cited in a report to make replicas (R12)	essential
Privacy	- Choose from public report or private report, visible only by the author and report recipients (R15)	essential

the interview process. In this survey twenty-three requirements were presented through a quite friendly web form. For each of the issues we showed the statement of the requirement, and when necessary a more complete description with additional information, in addition to the context to facilitate understanding by the participant.

The survey was made public through email messages, whatsapp and social networks. The target audience is made up of researchers, professionals and personal contacts of the authors. No specific targeting of public either by gender, age, income or education level was made. However, the target audience may be made up of people who use personal computers and smartphones frequently.

By the time of this writing, sixty-seven responses were received, participants used personal computers, tablets and smartphones to send their contributions. The retention rate was 66% on average of accesses made via personal computers, 57% of them actually responded to the questions, against 71% considering the accesses coming from mobile devices. Most of the accesses were made from communications made through Whatsapp, proving to be the best media for dissemination for such collaboration.

The average response time to the form was about 7 minutes showing that each user spent on average about 18 seconds for each question. The platform used allowed it to be recorded in the questionnaire opening time and the instant of final submission of responses. All the people answered the questionnaire voluntarily and no sort of benefit was offered to the participants. The only convincing argument used was that by answering these questions the participants would be part of a collaborative design process and would be contributing to the development of a solution that addressed the problem of monitoring the wait time of customer services.

For each of the questions asked by users on the requirements, the participants could evaluate the items with a score, on a range of 1-5 on the level of importance of that aspect in the solution as a whole. To facilitate the understanding, a description for each of the levels was made, namely: 1) unnecessary; 2) optional; 3) necessary; 4) very important and 5) essential.

Before the results were analyzed, a screening process was conducted to remove unwanted contributions from participants. To do so, contributions were eliminated which met at least one of the following exclusion criteria:

1. response time of less than 3 min;
2. minimum use of three different classifications, considering all the questions; and
3. a minimum of 75% of answered questions.

After the screening process, 13% of the responses were eliminated for satisfying at least one of the exclusion criteria. The main reasons for not contributing expressed by some contacted users included the preference for not responding qualitatively by not knowing very well the general context of the proposal, or for considering the questionnaire to be very extensive. Our claim is that due to the overhead of messages and requests that people receive every day, some people were not sufficiently motivated to invest the necessary time for proper consideration of the issues.

Considering only the answers that did not meet any of the exclusion criteria, let's see the results. As supported by [38], methodologies that employ ordinal data should work with the modal value (median) as a measure of central tendency, because the necessary arithmetic manipulations to calculate the average (and standard deviation) are inadequate for ordinal values, which represent oral statements. Thus, we chose to compute the most frequent value answered by users for each requirement. The results can be seen in the Table 1.

Table 2 displays the category in which the requirement was classified, the requirement's description, and the result obtained in the aforementioned survey. The survey validates most of the requirements obtained during the interviews: 18 requirements were classified as very important or essential, which corresponds to 78% of the total. Four requirements were classified as required; only one requirement was classified as optional and none was classified as unnecessary. The result was rewarding for us, because it showed that the ongoing work is on track and shaped to have a good public acceptance once the implementation of such requirements is concluded.

5. The proposed solution

In this paper, we propose a system for users of day-to-day services, to report the time taken to start to be serviced. The long waiting times have been the subject of widespread criticism from society due to the low quality of the services provided.

5.1 Places and organization (data) bases

In most cases, a queue is associated with a physical location and a service provider company, but in some cases this *waiting* event cannot be directly associated with the same physical location.

For example, the wait time reported by users of customer service channels usually are not associated with physical locations, for the most part this service is being done remotely. In this case the association of a wait time report should be done only with the organization, not associated with some geographical position.

Thus, in addition to the "places" database, it is also necessary a "companies" database. Many institutions are building profiles on social networks, making these networks an excellent "organizations" database. Fortunately, these networks provide structured access mechanisms to these databases – for instance, Facebook provides *Facebook Graph API*. The integration feature supplied by Facebook provides information about the pages and sites registered in this network, to name a few.

This information is structured in a graph where one can retrieve nodes and edges. This graph is traversed from a node that corresponds to the user himself (which makes the search), thus allowing the results of this search to be in greatest part relevant and consistent with the actions taken by the user previously on the network.

There are other databases accessible by API that cannot be neglected such as Google Plus API, Foursquare, and LinkedIn API. All of these integrations are accomplished through open standards and are easily accessible.

The first database of places explored in this work is the *Google Places API*, which was successfully deployed and – in the current development - already provides information on 80 million sites and points of interest that are frequently updated by listings verified by the owner and by moderate contributions by users.

5.2 Scenarios

The problems related to long waiting times in services are generally more common in large urban centers. The growth of these large cities with no proper urban planning has caused serious problems, such as the insufficiency of currently available resources to meet, in a timely manner, all the generated demand. It is possible that people who live in small, usually rural communities or localities that have a successful urban planning project are not frequently subjected to such problems. In this subsection, two practical scenarios are proposed, which can be considered a commonplace in medium and large cities.

Scenario 1: John looks for restaurants

John has just signed up for *Demorô* and is about to make his first access. He plans to go to a nearby restaurant, but he does not want to spend much time in an establishment which is congested. Before leaving home he does a search for nearby restaurants, and, through the application, he manages to view waiting time notifications recently posted by application users. John now has more information available to make his choice of restaurant. In this scenario, John chooses a better place and time to take his parents for dinner, taking into account the information on waiting times.

Scenario 2: Maria denounces the poor service at the bank

Maria is already a user of *Demorô* and is waiting in a queue at the bank Lerman. Upon entering the line of the bank, she triggers the button on the application responsible for starting the waiting time count in attendance. After a 40 min wait, she is finally called to be attended. Now she tells the application that her wait is over, and she finally publishes the time taken for the service through her profiles on social networks. Maria faces queues in this agency every day, and sees in *Demorô* a way of complaining and protesting because she can disclose to others the poor service provision and even disrespect to consumer rights. Other users can view these reports and choose to do their operations from other banks branches. Since the bank does not want to lose customers, it invests in improving customer service by hiring more employees and expanding its infrastructure.

In both scenarios mentioned above, one can observe how the system *Demorô* may assist users in finding the best places, days and times to spend less time in queues or on other waits on attendance. Contributions made by a user who reports long waiting times generate a few chain consequences.

First, the user making the report has the feeling of accomplishment for doing his part denouncing abuse. Second, other users will also benefit from this action, because they will know in advance that particular establishment is failing to maintain the quality of a service at a particular time of high demand and, therefore, can choose other places and occasions. Third, the managers will perceive the loss of customers, which at other times were undergoing long queues due to the inability to react in time (stemming from the surprise factor). Fourth, the administrators of these institutions will take steps to improve their services in order to avoid losing customers. Finally, users will be more satisfied because they will face shorter waiting times by using services that often undergo improvements and adaptations. Also, what can be observed is that the solution proposed in this paper ends up assisting in a balancing of demand, as users choose the best place and time to attend these places.

5.3 The architecture

The proposal presented in this work is divided into two main modules. The first one is a central infrastructure to store information about places, queues and wait time reports. There are four main entities that are included in the system: *Location, Service, Wait*, and *User*. Information about the places is obtained in real time, as the user performs a search in the application. During project development, it was considered a previous effort of building a database of places, but, in this study, we chose to adopt an on-demand construction approach for building the places' database.

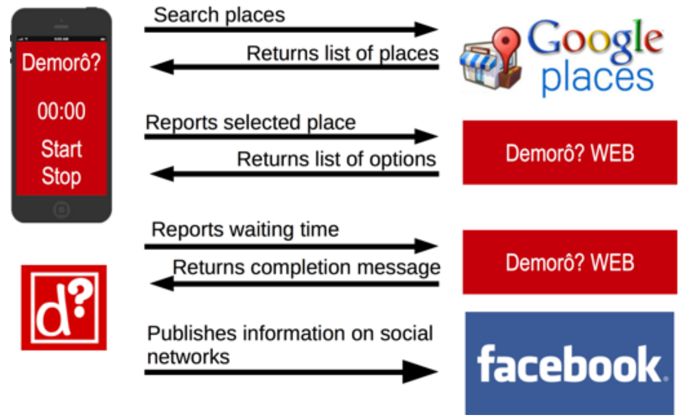

Figure 2. *Architecture of the Demorô application.*

Table 2. *Strategies for inferring services*

Line of Business	Services
Bank agencies	1. Bank Cashier; 2. Customer ATM; 3. Service Manager;
Restaurants	1. Self-service meal; 2. meal a la carte; 3. checkout line;
Service providers	1. Call by telephone; 2. Call by email; 3. Call by chat;
Delivery	1. Delivery time;
Health	1. Medical consultation; 2. Medical examination;

The same rationale was applied to the construction of the services' database, as this repository is also created on demand depending on user-triggered actions. When a user searches for a place, as soon as this is selected, the system checks whether the services' inference process has already been executed for that place recently. If this process has not yet been executed recently, or has never been run, the services' inference process is triggered.

This process is performed transparently to the user and requires no intervention on his part in this process. A proper heuristic allows the association between place details, such as its business areas and potential services offered by the company. The listing with the inferred service options for that place is available instantly to the user, even when the queue's inference

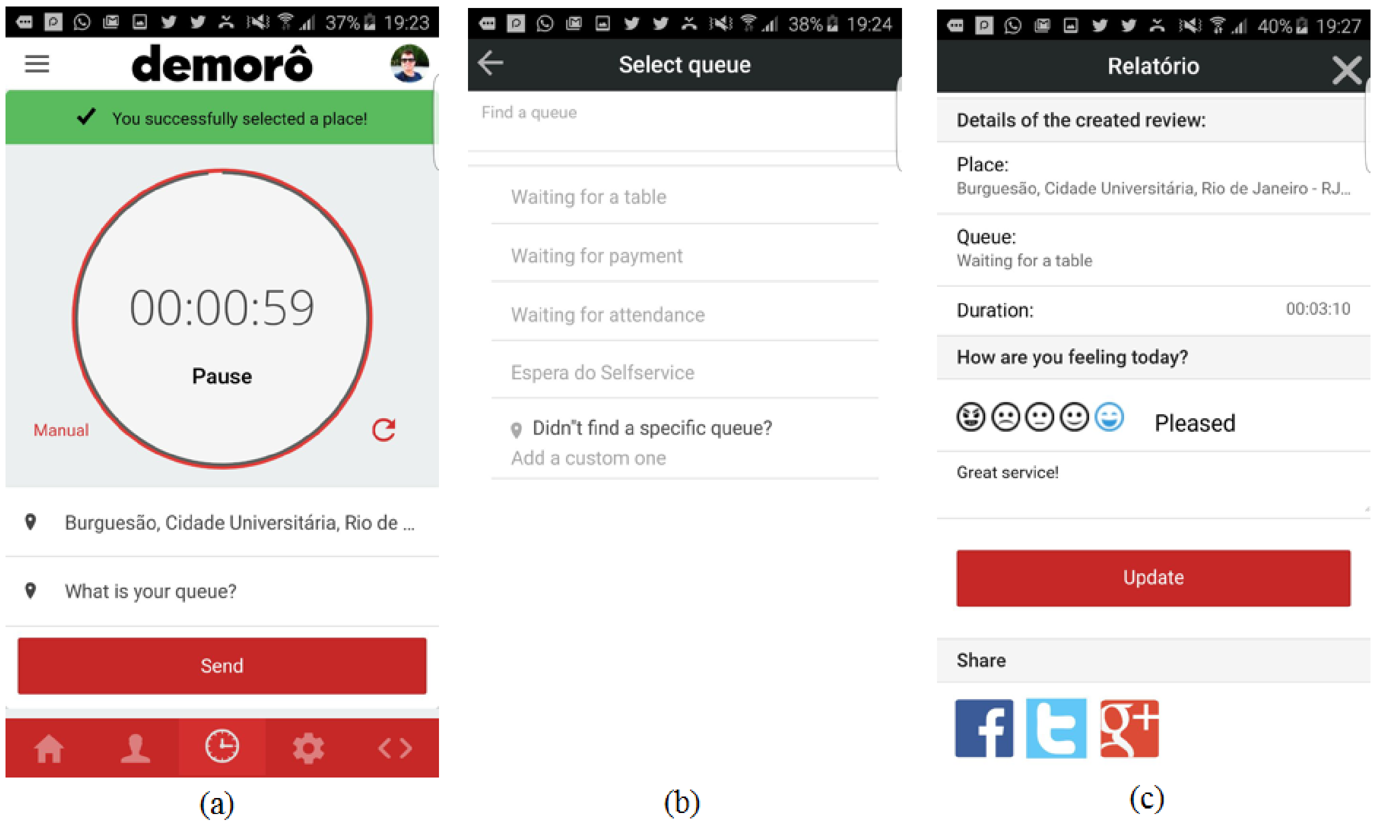

Figure 3. *Reporting a wait time on Demorô.*

process is performed. The on-demand approach for constructing databases of places and services allows the database to be made up of records carefully selected by a crowd. Unlike a database created by some crawler, the strategy chosen in this study enables a scalable growth of the database, and a guarantee that the data contained herein are prioritized by people.

One of the most important entities of the model is the *Wait*, which represents wait notifications reported by users. Due to the *schemaless* nature of the above mentioned entities, we opted for using a semi-structured document-oriented database.

The second component of the architecture is the mobile application. This application is usually installed on the user's mobile device, or can alternatively be accessed directly by the browser via a desktop computer, notebook, smartphone or tablet. This module is responsible for the whole interaction with the user, search for nearby places, service selection and wait time notifications. The application allows the wait time notification to be made anonymously or in authenticated mode. Even when the user contributes in authenticated mode, the system does not publish information about the user who made the contribution. The goal is to ensure the privacy of users of the platform.

The main application dialog, depicted in Figure 2, is to search for services and information about the wait time of a service. The services are linked to the site and company where they are provided, and this information is obtained through Google Places API.

After obtaining the information on the places, an inference is made of the likely services, based on the place name, description and list of line of business. Table 2 illustrates some examples.

6. Implementation of the prototype

The proposal presented in this work was implemented as a mobile application (named *Demorô*) using technologies like PHP, Symfony, Apache Cordova, Angular JS, Ionic Framework and MongoDB. A bilingual version (English and Portuguese) is now available for free download in Google Play and App Store since November 2015. To download, just search for "Demorô" in the official application stores of Android and iOS mobile operation systems. Figure 3 depicts the interface for reporting the wait time on an Android smartphone.

Figure 3 shows the natural flow for sending a waiting report. In (a) you can see on the main screen the timer and the widgets for selection of a place and a queue. In (b) you can see the list of inferred queues options automatically set by Demoro based on the selected location. Finally, (c) displays the confirmation screen, options for evaluation of waiting and the buttons to share the report on social networking services like Twitter, Facebook and Google+.

7. Discussion and conclusion

This paper presents a strategy to leverage the crowd collaboration to monitor the wait and service time in the provision of public and private services. The solution consists of an environment in which users can report the time spent waiting for the provision of a particular service. As said before, for the strategy to be successful, this account should be done through a simplified interface, preferably mobile, that takes advantage of the user's location information.

A significant contribution of this paper is a set of validated requirements, obtained through people with selected characteristics, which is the result of a participatory design process confirmed by a survey involving over seventy people. The reports gathered from the interviews were very fruitful and enabled a much deeper understanding of the involved issues, which facilitated the design of solutions adhering to the expectations of these users. The validation step of these requirements was very rewarding because 96% of the raised requirements were assessed as "necessary", "very important" or "essential" for a given set of participants.

The survey process also took into account the literature review of the area, and requirements could be extracted from other works dedicated to solving the same type of problem. The set of raised requirements could serve to guide the work done by other researchers, and help in producing a comparative analysis between similar solutions. Finally, the literature review also allowed us to identify the leading research groups on the subject, opening doors for these groups to carry out more cooperation with each other.

An implementation of the requirements raised in this article is being produced and is in an advanced stage of development, as shown in Figure 3. At this stage, about 61% of the requirements are implemented satisfactorily. A bilingual version (English and Portuguese) is now available for free download in Google Play and App Store since November 2015. To download, just search for "Demorô" in the official application stores of Android and iOS mobile operation systems.

The application interface needs to be improved, so that the user interaction becomes as natural as possible. In future versions, the system may automatically detect a "wait" whenever realized that the user is standing in a location already known by the application and in which *waiting* contributions have been made recently. When observed a significant change in his position, the user is prompted by the application to confirm the details of his contribution.

An issue that deserves further investigation is the evaluation of when a waiting time notification may be legitimate, or when it does not represent an actual event. The system should be able to detect these undesirable contributions from users. A possible solution is to establish an index to weigh the contributions made by users, according to their level of reliability and relevance - so that the calculation of the average waiting time is as fair as possible. Even when deemed reliable, the relevance of a given waiting time reported by the user may change as this contribution is no longer current.

Another issue that should be addressed is the prediction of demand for services in order to infer the future waiting times. This prediction can be made explicitly when, through the application interface, users previously report that will use a service on a particular date and time. Another approach that also seems promising is the analysis of time series of "wait" notifications already reported in order to identify user behavior patterns. The idea is that one can associate the demand for a particular service according to days of the week, times and seasons. In many day-to-day services we can observe recurrent patterns according to holidays, vacation seasons or weekends.

Some other issues are also important for the success of this approach, such as: How to deal with cases where the system does not have a sufficient number of recent samples to calculate accurately the average waiting time at a given moment? How to make good use of galification strategies to attract and retain users on the platform? How to handle users who do not contribute, using the system only for queries? How to extract useful information from the participation of users who only make queries to the system? This latter strategy is known in the literature as *piggyback crowdsourcing*.

By knowing the most frequently used services, and by acquiring the ability to predict the waiting time, users will be informed in advance about the waiting time, and will be better equipped to plan their daily schedules, being able to rearrange appointments when necessary. It is also possible that some users modify their habits, avoiding peak times, giving greater balance in the demand for a service, resulting in decreased waiting time, which benefits all users.

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