



CROWD4ROADS  
PROJECT

WHITEPAPER

# Incentives for Crowdsourcing

Bridging the user gap for crowd-based road  
quality collection initiatives with gamification  
and an anonymous rewarding system

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This whitepaper provides an overview perspective on the foundation of crowdsourcing and crowdsensing, detailing related notions such as collective intelligence and citizen science. As all crowd-based initiatives are usually built upon a core of volunteers participating to an “open call” to perform tasks, crowdsensing in particular relies on the willingness of participants to invest time and interest in a cause, sacrifice limited resources of their mobile devices, and provide implicit or explicit efforts, including ignoring risks that impact the privacy of their data. This document describes how incentives and rewarding schemes are adopted in this context to attract a community of users and to keep it engaged. Two incentive schemes in particular are described, both of which have been developed within the CROWD4ROADS project: a game mode that transforms collected data into generated terrain for a 2D platform game and a voucher exchange system that acts as a platform for any initiative for the common good. Both incentive schemes are fully anonymous and integrate within a fully anonymous data collection scheme.

# Crowdsourcing and volunteers

According to one of its definitions, when a company or an institution of any kind takes one function once performed by its employees and outsources it to an undefined group of people, the activity is said to be *crowdsourced*. The term “crowdsourcing” was **first introduced in 2006**, together with this definition, by Howe in *Wired Magazine* [HOWE2006]. As its inventor postulates, crowdsourced activities must be **outsourced in the form of an “open call” to action** and the call’s target must be a large network of potential laborers, who can take up the call. Whether the job is done in collaboratively or individually is not important.

One of the most successful attempts in the realm of crowdsourcing is Wikipedia, an encyclopedia built out of the contributions of thousands of volunteers and held together by the work of careful editors [KITT2008]. While not all crowdsourced work is equally successful—for instance, an attempt at a collaborative novel quickly showed the limits of such distributed work [PULL2007]—the approach is often successful. Also, the work performed by crowdsourced laborers is not limited to novel (or encyclopedia) writing, but can include providing ideas, voting for contributions, verifying information, or even performing actions as simple as providing funds, as in the highly successful “crowdfunding” initiatives that have gained appeal over recent years. Even highly specialized work such as academic peer review can be seen as a form of crowdsourcing.

## Mobile Crowd-Sensing

One of the many declinations of crowdsourced work requires users to “sense”, in order to **collect data and provide information**. This approach has similarities to what is commonly known as “citizen science” and in fact can be seen as deriving from early scientific data collection projects of democratic nature. On 29 September 1987 the New York Times reported about the attempt, sponsored by the National Audubon Society, to induce volunteers to collect rain samples across the United States with the aim of studying the impact of acid rains.

Even earlier attempts of driving the interest of common citizens towards activities that could turn into data collection campaigns for scientific work include the “Christmas Bird Count”. This initiative by ornithologist Frank Chapman turned popular hunting expeditions of the 19th century into bird counting exercises. In a similar manner, American US Navy officer and oceanographer Matthew Maury devised a common “log book” to be used on US Navy ships. Navy officers would use these logs to input easily measurable local information such as weather conditions and sea currents. Thanks to the wealth of information collected he was eventually able to produce the “Wind and Current Chart of the North Atlantic” in 1847.

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*Every ship that navigates the high seas, with these charts and blank abstract logs on board, may henceforth be regarded as a floating observatory. A temple of science. ~ M. Maury*

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Citizen science has two-fold implications: first of all, **citizens can be part of scientific research** and can produce reliable scientific knowledge, with very tangible actions. Secondly, scientific **research should be responsive to concerns, needs, and interests of citizens**. The coöperation of citizens and the academic community can indeed drive towards better research, with very palpable impact on everybody's lives.

This kind of work is made tremendously easier by the ever-growing presence of “smart” devices, which are always with their users, always on, always connected, and covered with a wide array of powerful sensors. So-called **Mobile Crowd-Sensing (MCS) is a large-scale data collection paradigm** that exploits the power of personal devices, made available by volunteers, such as smartphones, smart wearables, vehicles, and so on [GUO2015]. In this scenario, mobile device users contributing to the initiative are easily able to share local knowledge, such as noise levels, traffic conditions, light, or other local information about the user's context and ambient.

Crowdsensing has been the main driver of several successful initiatives: the collection of traffic information, political polling, air quality data

collection (see the [HackAIR project](#)), collection of noise, light, and other ambient information through simple sensor stations (see the [Smart Citizen project](#)), analyzing the spread of common influenza [HIRS2018], or continuously monitoring the quality of roads. All these are examples of the same data collection mechanics, made possible by the availability of inexpensive sensor technology through mobile devices or off-the-shelf electrical components and the ease of collecting data through an Internet connection.

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*[Mobile Crowd-Sensing is] a new sensing paradigm that empowers ordinary citizens to contribute data sensed or generated from their mobile devices and aggregates and fuses the data in the cloud for crowd intelligence extraction and human-centric service delivery. ~ B. Guo*

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For instance, many tools have been developed with the aim of **monitoring road quality** adopting a Crowd-Sensing paradigm. The earliest attempts include the “Pothole patrol” developed at MIT [ERIK2008]. A full-scale platform has been developed in 2014 at the University of Urbino under the name “SmartRoadSense” and has been active for more than 5 years [ALES2014]. Many of these solutions, including SmartRoadSense, collect information using smartphone sensors, such as accelerometers and GPS, to sense the vibrations that affect users (and the car they are driving). This data can be effortlessly collected by any user, with the cost of devoting some of the device’s computing power to the data collection task. Once gathered, collected information provides a good representation of the road network status, often identifying road damage or surface deterioration quite well [KLOP2018A].

## Volunteering

Mobile devices notwithstanding, Crowd-Sensing would still not be possible without the good will of volunteers: people involved in a MCS campaign contribute to the sensing operations by providing access to the limited resources of their smart device. Users must make *implicit* efforts

(e.g., energy consumption, bandwidth, acquiring devices, etc.) or *explicit* ones (e.g., giving input, setting up the device, getting informed, enabling the collection process, etc.).

Many MCS solutions are *grassroots* initiatives, that naturally **rely on the willingness of volunteers** to devote some time and attention out of personal interest. However, in many other cases there is no substantial community adopting a Crowd-Sensing solution naturally. Or volunteers may not be motivated enough to contribute in an active way. In those cases, Crowd-Sensing solutions risk not being able to reach the minimum utilization rate at which they would be able to produce useful results.

# User incentives

As in the case of Wikipedia, the bulk of the work in many crowdsourcing initiatives is performed by volunteers, without any direct compensation. In most cases volunteers provide their time and efforts in good will, because of their confidence in the project. In all other cases, **user incentives are needed to engage users** and to convince them to continue providing their work in a regular manner.

A user incentives study by Zhang et al. further how participating in a sensing system entails costs and risks for users, that must be offset by adequate incentives. The study divides user incentives into 3 major categories: a) **Entertainment incentives**, whereby the crowd sensing task is turned into a game, such that users can contribute to the initiative while playing; b) Providing **services in exchange for work**, which requires that sensing platform and users are able to provide mutual benefits to each other; c) **Monetary incentives**, whereby the sensing service pays a given amount of money (or an equivalent) in exchange for work [ZHAN2016]. Guo et al. include additional incentive types, such as **ethical reasons** and privacy protection of users.

While Crowd-Sensing systems usually have the necessity of addressing user privacy issues, many incentive systems proposed in literature or adopted in the wild often only tangentially address the issue, if at all. On the other hand, simply combining existing privacy protection schemes [CORN2008] and simple monetary incentives may not always be possible and may require a more profound re-engineering [LI2014].

In the context of the CROWD4ROADS project, for which the previously-cited SmartRoadSense platform provides the Crowd-Sensing aspect, the development of effectual incentive schemes that fully protect the privacy of users is of utmost importance. The project focuses on a combined approach that mixes “gamification” to engage and entertain users and a fully anonymous voucher scheme as a form of monetary reward.

## Gamification

Entertainment incentives are based on transforming a sensing task into a playful activity, that entertains users and ensures that they keep coming back for more (and collect more data). “Gamification” indeed is the application of typical game elements, such as competition with others and scoring points, to other non-game activities.

Drawing on this theory, CROWD4ROADS adopts gamification as an innovative strategy for fostering user-engagement and promoting growth [CLAR2017]. The SmartRoadSense mobile app will include a “Game mode”, allowing players to play in a simple 2D physics-based driving game.



SAMPLE GAME SCREEN FROM SMARTROADSENSE.

In particular, SmartRoadSense will

**leverage the collection of road quality data as source for procedurally-generated game levels.** The user’s data collection activity will thus become a seemingly unlimited source of information that will be directly used to create unique and heterogeneous game experiences [LEWI2018]. Generated levels will follow the nature of previously collected data tracks: driving on smooth road sections will generate equally smooth and easy game level segments, while rough road tracks will introduce more difficult mounds and peaks. Players will be able to “ride their data”, making them more aware of road quality and the direct relation between road monitoring and game level generation.

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*There's no one without purpose in a game.  
That's what Gamification is all about.  
~ Vineet Raj Kapoor*

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However, many game elements often adopted are not compatible with anonymous data collection: for instance, presenting leaderboards, public competitions between players, or player profiles with achievements, all require storing information about the player’s activity and his or her identity. In the case of SmartRoadSense, user anonymity will be preserved by avoiding these game elements entirely or constraining them. For

instance, information about player activity that must be stored (for instance about collected data tracks, gained points, upgrades, and so on) will never be transmitted to a central service or to other players.

## Worth One Minute

On the monetary incentives front, CROWD4ROADS has designed a **general-purpose rewarding platform based on a voucher exchange system**. Vouchers are called WOMs, an acronym for “Worth One Minute”, and they will be granted to volunteers who dedicate one minute of their time to any kind of activity towards the common good.

WOMs are **fully anonymous**, but they retain information on the *aim* for which they were earned and on the *time* and *place* where this happened.

These “aims” of collective interest are established by an ethical committee and the platform is open to be adopted by any tool or initiative that promotes recognized aims. Such as, for instance, road quality monitoring.

WOMs are managed by a mobile app, installed on personal device of volunteers, and they can be monetized thanks to third-party merchants that are willing to reward volunteers (thus giving their own contribution to the aim) by granting discounts on goods and services. Merchants can apply filters to collected WOMs (filtering on aim, place, and time) in order to accept only those WOMs which are more coherent with their own motivations and aims.

The [WOM platform](#) is based on open technologies and is currently under active development [KLOP2018B].

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