How Crowdsourcing Can Help Public Transport Innovate Successfully in an Era of Rapid Change

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Abstract

Crowdsourcing is an organized way of involving people in decision-making and production. Crowdsourced products, like Wikipedia, are replacing established products. Crowdsourced services, like Uber, are replacing established services. Crowdsourced advice, like Trip Advisor, is replacing established experts. Crowdsourcing is becoming ubiquitous as people and organizations realize that it helps them make better decisions and produce better products.

This paper is predicated on the belief that crowdsourcing is the key innovation needed for public transport to thrive in this age of rapid change. It presents a model structure for helping understand crowdsourcing and examples of how public transport organizations can use crowdsourcing. The paper presents a broad survey of crowdsourcing with the objective of helping practitioners and researchers implement and understand crowdsourcing projects in public transport.

How Crowdsourcing Can Help Public Transport Innovate Successfully in an Era of Rapid Change

1.   INTRODUCTION

Crowdsourcing is the key innovation of our age. It is changing the world more than any technological invention because it is changing society, how we behave, what we do, how we do it. The electric car is an important technical innovation, but how we use it – which, if companies like Uber, General Motors, BMW and Daimler are right, will be based on crowdsourcing (sharing) – will be the more important innovation.

The rapid changes brought about through crowdsourcing are becoming visible and the speed of these changes will accelerate. Organizations unprepared for these changes will crumble when challenged by crowdsourced-based businesses. (1) Consider how peer-to-peer ridesharing has impacted the taxi industry in many cities.

But, crowdsourcing is not a panacea. While there were many problems with taxicab service, peer-to-peer ridesharing brings its own problems and most transport organizations (e.g., government taxi regulators) are woefully unprepared to address these problems.

The purpose of this paper is to help public transport organizations understand crowdsourcing so they will be prepared to innovate successfully in this age of rapid change. The paper begins with an introduction to crowdsourcing. Next it describes five uses for crowdsourcing with examples from public transport. Finally it presents conclusions.

What is crowdsourcing?

The most well-known example of crowdsourcing is Wikipedia, a crowdsourced on-line encyclopedia. (2) Back in the old days of the 20th Century encyclopedia entries were written by experts and produced by large publishing companies. Encyclopedias were expensive and mainly used for research (academic) purposes.

Wikipedia revolutionized how encyclopedias were produced and how they are used. Wikipedia is written, edited, reviewed, and revised largely by volunteers. More importantly, it's much more frequently used than traditional encyclopedias ever were (it's one of the top 10 Internet websites). And, most encyclopedia publishers have gone out of business.

But, what happened to quality? When Wikipedia started many articles were written comparing the accuracy of articles in Wikipedia to old fashioned encyclopedias. Most found that the accuracy was similar (it was surprising how many inaccuracies there were in traditional encyclopedias). In the meantime Wikipedia has improved to increase accuracy by, for example, creating subject editors and a more structured participation process. But, it's still a mostly volunteer-driven project. (https://en.wikipedia.org/wiki/Reliability_of_Wikipedia)

Wikipedia is not perfect, but it's an excellent example of how crowdsourcing can rapidly and significantly change society. So, what is crowdsourcing? Jeff Howe first published a definition in a companion blog post to his June 2006 Wired article "The Rise of Crowdsourcing" (https://en.wikipedia.org/wiki/Crowdsourcing). This author summarizes the main points as:

> *Crowdsourcing is using other people to help your organization do something.*

This simple definition belies its complexity. As the next section outlines, organizations that wish to successfully use crowdsourcing must: have a willingness to accept help, create an

easy and engaging method for others to provide help, develop internal processes and systems for using the outside help, and, ultimately actually produce a product. There are serious challenges in all these areas. (3) (4)

Four Requirements for Successful Crowdsourcing

The author has identified four key requirements for organizations to use crowdsourcing successfully. First, organizations must be willing to accept help, although the really successful crowdsourcing organizations are those that aren't simply willing, but rather hungry for help. They are built upon the idea that they can accomplish more if they use resources (of all types) from everyone.

Second, organizations must build systems that enable and encourage people to provide help. This is where technology has made a difference: before the Internet, organizations had no way to communicate efficiently with their customers, suppliers and stakeholders. Now they do. However, even with the Internet, communications is not easy; it requires high quality information design and processing to be engaging, efficient and useful.

Third, an organization must integrate the supplier-provided help into their own processes with the ultimate objective of, fourth, producing a product. Sounds simple, but it requires imagination, creativity, and, most importantly, a culture willing to embrace outside ideas.

Types of Crowdsourcing: A proposed structure

The essential element of crowdsourcing is involving people from outside the organization in producing a product. The author proposes a five part structure for categorizing crowdsourcing activities:

- **Reporting** – Reporting is providing simple feedback to an organization. A good example is reporting a pothole. The main characteristic of reporting is that it's unnecessary to discuss the reported data since what needs to be done is clear.

- **Collecting and analyzing data** – Information technology has made it possible for anyone to collect, analyze and interpret data. This changes their relationship to government agencies and opens new possibilities for creativity and innovation.

- **Collaborating** – Collaborating is used when individuals and organizations must work together to solve a problem, create a product, approve a plan or just get something done.

- **Acting and providing** – Acting and providing consists of having individuals actually provide a service or create a product. It's often referred to as peer-to-peer services.

- **Intending** – Intending consists of crowdsourcing people's intentions. It replaces the need for predicting what customers want, instead, customers say what they want and organizations produce it.

An important observation about these categories is that there is nothing new here. Organizations have always obtained these things from the outside. What's new is that now everyone can participate in these activities.

This five-part structure shows an increasing level of user involvement and engagement. The level of engagement is a critical element in crowdsourcing: the more engaged the user, the more they will help the organization. Again, this is not surprising; customers who have a

(positive) personal relationship with a company or product are much more likely to buy the product. This is why developing high quality crowdsourcing applications is important – they help build good relationships.

Crowdsourcing for Public Transport

Many transport agencies are currently using crowdsourcing. (5) (6) However, this paper argues that public transport organizations must more fully integrate crowdsourcing into their business models if they are to compete successfully with peer-to-peer transport providers (who are starting to provide public transport-like service) and be prepared for the advent of self-driving cars (which will fundamentally change urban transport – although we don't know how). Public transport is especially susceptible to these changes because, in many places, it is not especially effective or efficient. In other words, it is ripe for disruption. The following sections describe how crowdsourcing is, or could be, applied in public transport.

2.   REPORTING

Reporting is providing simple feedback to an organization about a problem they are responsible for solving. For example, a subway customer reports that an elevator is broken or a train is dirty. Customers have always been able to do this by calling a service number or writing a letter, but websites and applications make this quick and easy. Unfortunately many organizations fear the administrative burden of dealing with the reports and/or do not want to be criticized in public (crowdsourcing is highly transparent).

The fear of criticism is valid, but the Internet has already made it possible for anyone to criticize organizations anytime. Therefore, a better strategy is to proactively seek criticism and use it to improve. The fear of administration is also valid, but the solution is to carefully design the reporting process and applications. Importantly, developing a new process also provides the organization with the opportunity to re-think and improve existing processes.

Reporting applications consist of two main parts:

- User input – a platform that allows users (e.g., city residents, transit agency customers, etc.) to report (non serious) problems to organizations via website and mobile applications.

- Administrative back-end – a database that helps organizations address the reported problems, keeps track of progress, and informs users on status.

Most agencies have generic reporting applications such as SeeClickFix customized to meet their needs. For example, Amsterdam's public transport operator uses a customized version of Verderbrut (a reporting application in the Netherlands) to identify and track issues related to its system.

Figure 1 illustrates the public transport reporting application FixMyTransport developed by the UK's MySociety (who also developed FixMyStreet). The application is no longer available although the code is available for an organization willing to continue the project. (7)
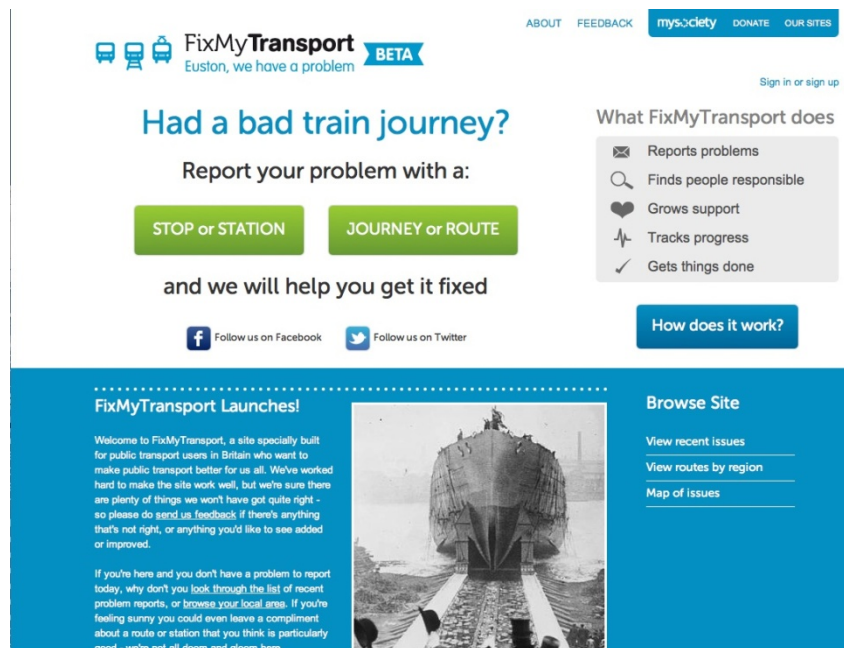
Figure 1   FixMyTransport is a reporting application developed by MySociety.

Crowdsourced reporting does not need to be simply entering data on a form. There are several enhancements that make reporting easier and more efficient including:

- Traffic Check – (Figure 2) is a mobile phone application developed in Graz (Austria) for reporting traffic signal problems. It uses GPS to accurately identify signal locations and provides a series of screens guiding users in providing information. It's available to the public, but the main users are city workers because it's easy to use.

- Public transport reporting applications – such as Tiramisu Transit (8), Moovit, and Swift enable users report status and qualitative information such as crowdedness, cleanliness and driver friendliness. In most cases this information is simply provided to other users, but some operators are using the data to help improve service.

- Public transport tracking applications – Moovit tracks users as they use public transport to obtain real-time travel time data (Waze is a similar app for highways).

- Street-bump – (also shown in Figure 2) is an application that uses the accelerometer in mobile devices to identify potholes and sends the location information directly to the responsible roadway agency. It was developed by the City of Boston and is an excellent example of using sensors to report problems.

These examples show how reporting apps are becoming easier to use, more efficient and more useful. These trends will continue as developers and agencies learn more about crowdsourcing. More examples are available at http://crowdsourced-transport.com.
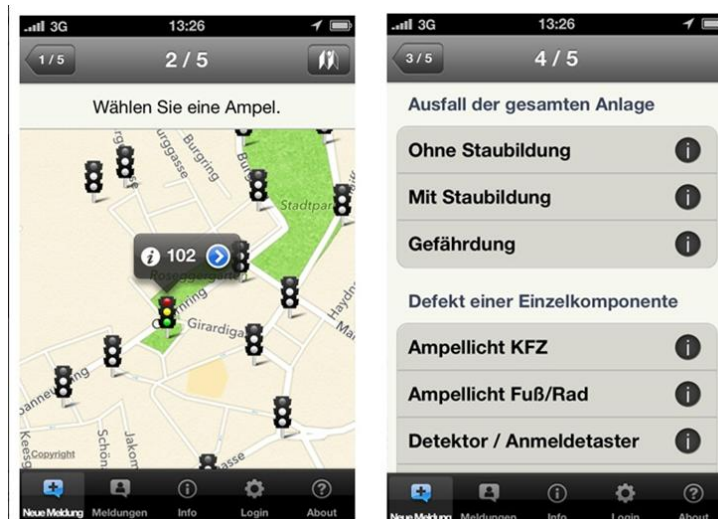
TrafficCheck provides easy entry screens.
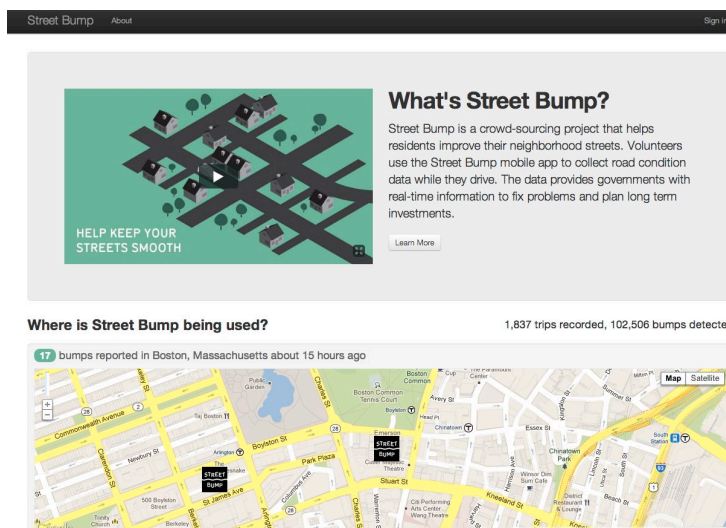
StreetBump uses accelerometer data to identify pothole locations.

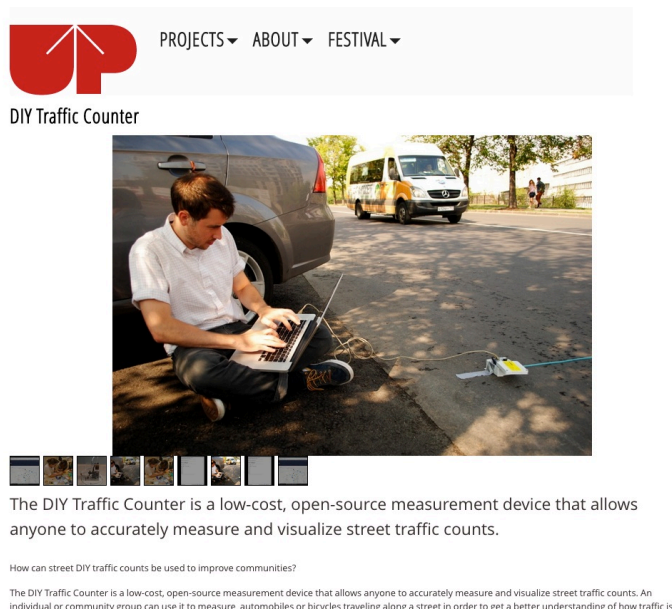**Figure 2   Traffic Check (top) and StreetBump (bottom).**

3.   COLLECTING AND ANALYZING DATA

Advanced information technology has revolutionized society's relationship to data. Cheap, small and accurate sensors make it possible for anyone to collect high quality data. Fast and powerful computers make it possible for anyone to develop new insights by mashing-up (combining) data from their own and/or open source data. Broadband Internet service makes it possible for anyone to share their data and conclusions quickly and easily.

The ability to collect and analyze data means residents can check official analyses and use this information to influence public decisions. The public is just starting to use data in this way, but this is a trend that will continue. Three examples of collecting and analyzing transport-related data are:

- Environmental quality – sensors are available to measure air quality, temperature, noise, etc. These data can be used to highlight the need for creating transport plans to reduce emissions.

- Traffic – devices have been developed to count traffic (vehicles, bikes, people) using tubes or by analyzing video data from cameras (see Figure 3).

- GTFS data analysis – GTFS (General Transit Feed Specification) is a specification for public transport data. When agencies provide an Internet feed (API) of their data in GTFS, this data can be analyzed by residents. It also encourages people to mash-up transit data with other data to identify trends and problems. (9)

The main take-away for transport planning from the increase in crowdsourced data collection and analysis is that residents will become much more heavily involved in the planning process – whether planners like it or not. The best approach will be to develop a process that acknowledges and benefits from this increased level of public participation. (10)

The DIY Traffic Counter is a low-cost, open-source measurement device that allows anyone to accurately measure and visualize street traffic counts.

How can street DIY traffic counts be used to improve communities?

The DIY Traffic Counter is a low-cost, open-source measurement device that allows anyone to accurately measure and visualize street traffic counts. An individual or community group can use it to measure, automobiles or bicycles traveling along a street in order to get a better understanding of how traffic is

Figure 3   Do-it-yourself traffic counter.

4.   COLLABORATING

Collaborating is used where simply reporting is not sufficient. It consists of working together to accomplish tasks where there are no clear answers, for example creating a transport plan. There are three main steps in a successful collaboration process:

- Engaging people to participate;
- Educating people about problems and possible solutions; and,
- Providing a process for people to discuss and agree on solutions.

Crowdsourced collaboration applications have been created for all three of these activities and some include all three activities in a single application.

Engagement

Engagement applications are designed to attract people to the collaboration process. Attracting people is one of the most difficult parts of transport planning. In spite of all efforts many people don't learn about planning projects until they are over. More importantly, many planning processes are too boring to attract anyone but the usual suspects. Two types of applications designed to attract people to the planning process are games and process applications.

Games are an excellent way of attracting participants. They are interesting and fun (and therefore one of the most used applications on computers and mobile devices). Transport games include BusMeister (illustrated in Figure 4), RingRide, O Marks the Spot, Meet-the-street. Games are an especially good way to attract unconventional participants to public processes (e.g., young people). (11) Process applications (described below) also generally include features to attract users.
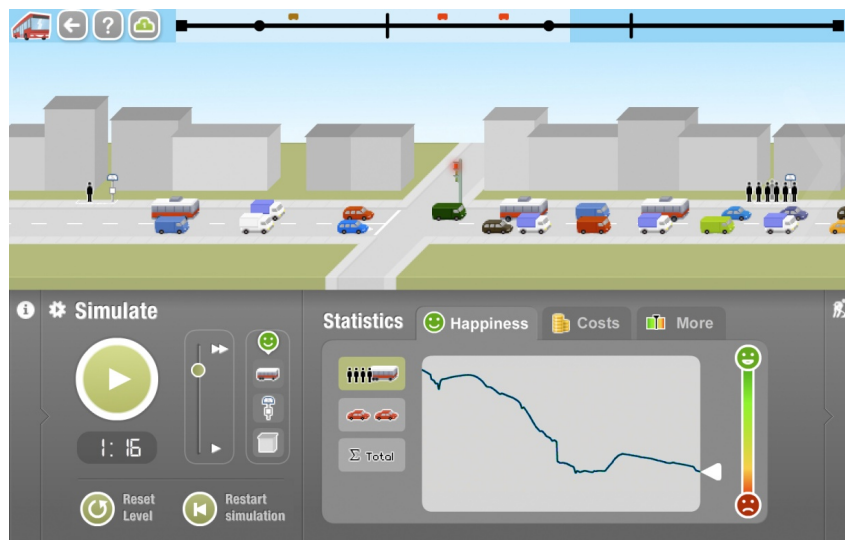
Figure 4   BusMeister public transport operations game.

Education

The second type of crowdsourced collaboration applications are educational. One of the most frustrating aspects of public processes (for participants and organizers) is a lack of knowledge about the problem being addressed and potential solutions. It's important that planning processes are open to creative ideas, but some solutions are just not feasible (e.g., building a metro line in a low density suburb).

Educational applications provide information in an interesting way. Examples include board games (12) and interactive games that teach people about tradeoffs (e.g., BusMeister game) (13), budgeting applications that ask people how they would like to spend a given amount of money, interactive visualization applications that help people imagine how something would look (e.g., Streetmix shown in Figure 5, sketch-up), and Internet information such as web pages or wikis. A particular advantage of Internet-based information is that it can be continuously updated so that new resources do not need to be created for every planning project.

Process

The third type of crowdsourced collaboration applications are process applications. Process applications provide:

- a structure for collaborative processes (e.g., a calendar of events, ground rules for participation, etc.);
- opportunities for providing input and evaluating the input of others (e.g., liking someone else's idea); and,
- links to more information (e.g., educational applications).

If process applications are well designed they make processes more engaging (at least not boring) and enable people to participate who might not be able to attend a traditional public meeting (e.g., due to meeting timing).

Figure 5   StreetMix street cross section visualization application.

The process applications MetroQuest and MySidewalk have been developed specifically for government and agency planning processes. They both have been significantly improved over time and today they offer a wide variety of tools that can be mixed and matched to create process applications for all types of transport planning processes.

While much progress has been made in developing crowdsourced collaboration applications, they are only starting to be used effectively by public transport organizations. One reason could be that these agencies have still not fully embraced the need for public participation, and especially the quite active level of participation that real crowdsourcing entails. This problem reflects the first principle described at the beginning of this paper, namely, to successfully crowdsource, an organization must be willing to accept help.

5.   ACTING AND PROVIDING

Acting and providing crowdsourcing applications are tools that help people actually do something like build a project, operate a service or support an activity. This section describes three types of crowdsourced acting: crowdfunding, peer-to-peer services, and organizing.

Crowdfunding

Crowdfunding consists of raising funds online for a specific project or activity. The most well known crowdfunding application is Kickstarter, which has provided over $2.5 billion for almost 109,000 projects since its inception in 2009. (14) Today there are several crowdfunding platforms including IOBY (In Our Back Yards) and Space Hive that specialize in civic projects such as parks, street furniture or other projects.

In transport, while it's hard to image crowdfunding large projects like light rail lines, it's already been used successfully for small projects such as bus stops (see Figure 7). Furthermore, often the most important purpose of crowdfunding is not raising funds, but rather generating and showing support for the proposed project. This is especially true for larger projects where other organizations can provide matching funds. A good example is Denver's 15th Street Bikeway. (15)

Crowdfunding of projects that have previously been funded by government raises the issue of equity: high income areas have more ability raise funds than lower income areas. Therefore government agencies must attempt to balance any inequalities caused by crowdfunding (e.g., if one neighborhood builds a high-tech bus stop via crowdfunding, the agency should focus on trying to improve its stops in other neighborhoods). This is clearly a subject for more analysis and research.
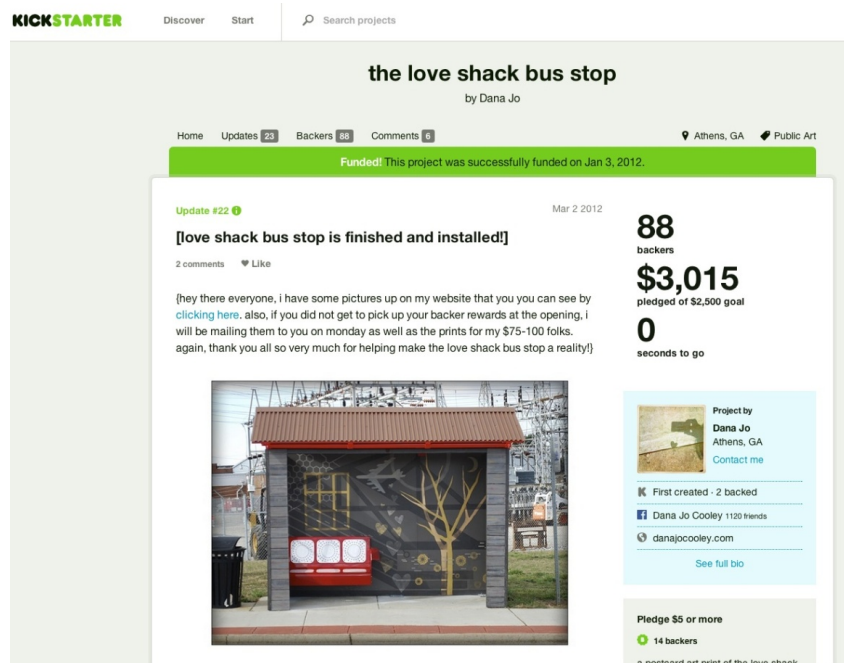

Figure 6   Love Shack crowdfunded bus shelter on Kickstarter.

Peer-to-peer Services

Crowdsourced peer-to-peer services use applications to connect people who want to provide a service with people who want to use a service. The most familiar peer-to-peer transport service is Uber, an application that matches drivers with people wanting a ride (essentially providing taxi service).

Peer-to-peer services are often lumped into a category called "sharing economy" although they do not always meet the strict definition. (3) The sharing economy is normally considered to be a no or low profit operation where people use things that belong to other people for limited amounts of time without paying or paying only a small fee. In most cases sharing services developed first and then for profit peer-to-peer applications were developed in the same business sectors. For example, the Couchsurfing application (low or no-profit) for sharing a room in someone's home developed before AirBNB (for profit).

Peer-to-peer applications provide a platform that facilitates creating a market for something. There have always been people who would like to rent a spare bedroom to travelers, but no efficient way for those people who want to rent a room to find the people who have the room. The Internet completely changed this situation. Companies like AirBNB or Uber are essentially brokers linking sellers (e.g., drivers) with buyers (e.g., passengers). These companies develop applications that facilitate this process.

There is much controversy over these new peer-to-peer services. Uber, for example, has significantly hurt the regulated taxicab industry in many cities, but, at the same time significantly improved service for customers. In many cities it was very difficult to get a cab at peak times, nor did taxi companies introduce new technologies such as standardized mobile phone payment and hailing applications.

Uber (and other peer-to-peer ridesharing companies) developed solutions to these problems and have attracted many customers. The lesson is to adopt more customer-focused business models before competition arrives.

On the other hand, it's critical to remember that peer-to-peer companies are companies. In other words they are interested in maximizing their own profits, and therefore need to be carefully regulated by government. The controversy around peer-to-peer companies today surrounds how much these companies need to be regulated.

Unfortunately, sometimes these large companies appear to have more power than their regulators. For example, Uber was able to defeat controls proposed by Mayor Bill de Blasio in New York (regarding limiting the number of drivers and surge pricing), (http://observer.com/2015/07/why-did-uber-beat-bill-de-blasio/). Similarly when Austin voters defeated a measure placed on the ballot by Uber and Lyft to reduce the controls placed on ride-hailing companies by the city, they withdrew from the market. (http://www.govtech.com/policy/Austins-Ride-Sharing-Proposition-Defeated.html) In short, cities will need to work together (and with the industry) to develop fair and consistent regulations.

Peer-to-peer ridesharing companies are also expanding beyond individual point-to-point transport to public transport-like service (carrying unrelated individuals to different destinations). In fact, 40% of Uber trips in San Francisco are using these shared services (Uber Pool). (16) Furthermore, many public transport agencies are experimenting with using these peer-to-peer services to provide last-mile or station feeder services.

Finally, the introduction of self-driving cars will have a huge impact on peer-to-peer ridesharing companies. One of the main costs for these companies is paying drivers. If there

are no drivers the cost of service will plummet, significantly increasing demand. Self-driving cars also gives these companies the opportunity to move from peer-to-peer businesses, to businesses that own a fleet of vehicles, in other words much more like a public transport operator. This business is described below under crowdsourced intentions.

In short, peer-to-peer services are likely to cause significant disruption in the public transport industry during the next few years. It is extremely important for public transport agencies and government to prepare carefully for these changes.

Organizing

Organizing consists of encouraging and supporting a group of people in doing something. This consists of political support such as coming to a meeting, contacting a public official, participating in a protest march, or active support such as getting people to participate in a clean-up day.

Many generic social media applications (e.g., Facebook) include tools like creating events to help organize people to participate in these kinds of activities. Similarly, other purpose-built crowdsourcing applications (e.g., collaboration applications such as Loomio) include tools designed to help support political activities.
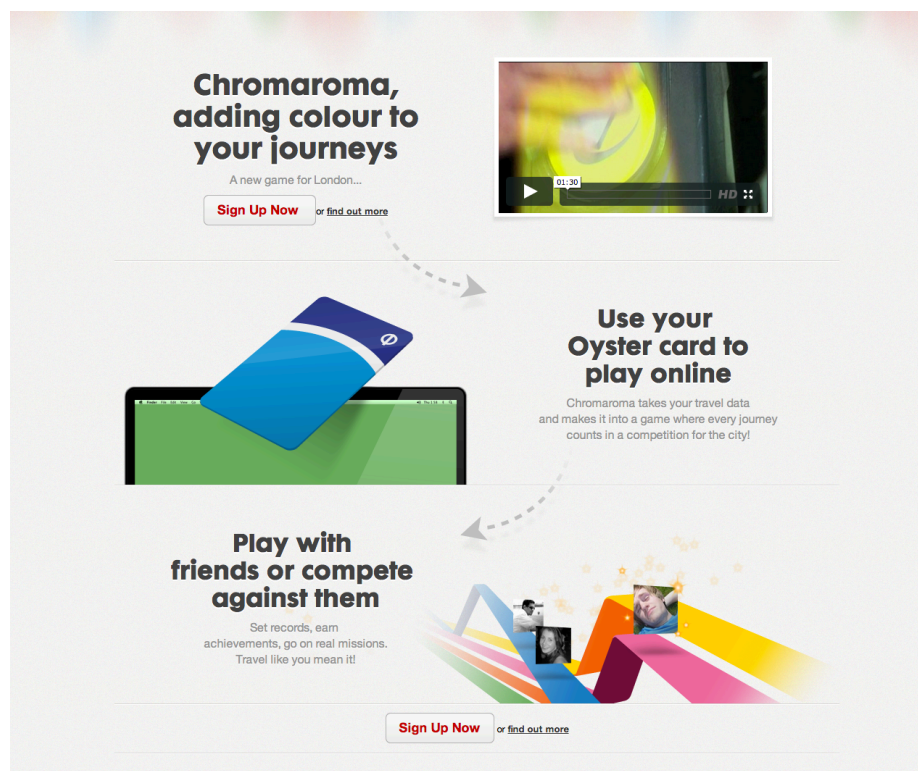
Figure 7   Chromaroma game uses London Oyster Card data.

An interesting approach for organizing is to use games to engage people and encourage them to participate. The game Chromaroma used London Oyster Card data to create activities around the London Underground such as creating teams to "take over" stations (Figure 7). It's easy to imagine designing similar games that would encourage public transport passengers to, for example, pick-up litter in stations that they "owned".

6.   INTENDING

Today transport organizations need to predict what their customers want. These predictions have become better, but remain approximations for really understanding customer behavior. What if customers could simply tell public transport operators what they wanted, with all their requirements and preferences?

Crowdsourcing intentions is asking customers what products or services they want.

It is straightforward to crowdsource intentions for manufactured products because producers and consumers share a common understanding of what the products are. On the other hand, crowdsourcing intentions for scheduled transport services is difficult because producers and consumers have quite different perceptions of transport.

For producers of scheduled transport (e.g., public transport operators), service is defined in terms of a vehicle moving from A-to-B at a specified time; in other words with a timetable. For consumers, transport is perceived as something that allows them to participate in some activity in a different location. Consumers use timetables to determine if they can use public transport and when to arrive at a station, but this is not how they perceive public transport service.

Instead, consumers have a qualitative perception of transport service (e.g., it's impossible/ possible/ convenient/ very convenient to use public transport to participate in such-and-such an activity). Furthermore, their focus is on the activity – not the transport. In order to crowdsource travel intentions these qualitative measures must be made quantitative by expressing them in terms that can be used to develop a schedule such as frequency, travel time, and hours of operation; and in terms of activities rather than moving vehicles.

Scheduling

In real time customers are able to specify exactly what transport services they want (I want to go to the airport now.) Peer-to-peer ridesharing businesses (e.g., Uber) can use these intentions directly to send a car and satisfy the customer. These companies are also moving rapidly into the field of providing real-time public transport-like service (e.g., Uber Pool). (16)

In scheduled transport services it's not possible for computer algorithms to develop schedules based on customer perceptions because there is no computer-friendly language for expressing how customers really perceive transport services when planning future travel. This makes it difficult for public transport operators to develop schedules that really satisfy customers and especially attract new customers.

A simple example is a bus that stops operating at 18:00. While it's theoretically possible for a consumer to use this bus to get to work, the consumer does not perceive this service as available because they could not use it if they had to work later than 18:00. This illustrates the problem with perception of scheduled transport: how can this qualitative perception be expressed quantitatively? These quantitative expressions must be developed for all the factors that influence consumer perception of scheduled transport.

Activity Focus

Transport is a derived demand, with rare exceptions people don't travel for the sake of travelling but rather to participate in some activity in another location. Today's transport systems are built on the basis of models that derive transport demand from socio-demographic data. This derived information is used because it was impossible to manage individual activities in transport models (before the advent of activity-based models).

However, information technology and activity based modeling can now be used to estimate transport demand. Therefore it's possible to use crowdsourced activity intentions to help plan public transport schedules. What's exciting about focusing on activities is that it gives operators some scheduling flexibility.

More specifically, it's not important that a vehicle arrives at its destination at a specific time, but rather that the customer arrives at her activity before it begins. This is seen in practice by passenger arrival rates at public transport stations. If the scheduled headway is less than 10-minutes, passengers arrive without consulting the schedule. In other words passengers have a certain amount of flexibility in their travels. This flexibility can be used by operators to re-plan schedules in the event of disruptions – if operators understand the underlying activities.

Implementation at Banedanmark

Crowdsourcing travel intentions for developing scheduled transport timetables represents a significant change. But, it makes possible the blending of the best of real time transport services (customer convenience) with scheduled public transport service (efficiency).

Banedanmark, Denmark's railway infrastructure owner, has started the process of developing and implementing this type of travel intention-based scheduling system. This effort consists of developing the technical language needed to quantitatively describe customer perceptions of transport service for computers, creating algorithms needed to convert these perceptions into future schedules, and then, ultimately creating crowdsourcing applications to collect intentions from customers.

Banedanmark is focusing on the first two steps, creating the language and algorithms to implement the approach. The first application will take customer needs as a given rather than crowdsourcing them. However, Banedanmark's system is being designed as a platform so new applications can be built using the system's data and processes. One of these new applications will be a system for crowdsourcing travel intentions. This new approach also opens the possibility of integrating customer activities more directly into the transport scheduling process, for example, starting a concert 5-minutes later if public transport is delayed.

Developing a system for crowdsourcing travel intentions is a significant technical challenge. However, another challenge will be privacy concerns of customers (will they be willing to tell us where they want to go?). Therefore, an important building block for developing this intentions-based transport system will be developing a transparent and mutually beneficial process. (17)

7.   CONCLUSIONS

Crowdsourcing is the key innovation in our rapidly changing age. It will be the driver for massive changes throughout society. But, like all innovations crowdsourcing must be used wisely to benefit society especially when it is being applied to public services such as transit.

For public transport operators, crowdsourcing can help improve service, increase efficiency and create better relationships with customers and key stakeholders. It is particularly important for operators to understand and implement appropriate crowdsourcing programs because it they will face competition from other crowdsourced businesses (e.g., Uber Pool). In other words, crowdsourcing will be fundamental innovation that helps public transport thrive in this age of rapid change.

This paper provides an introduction to crowdsourcing for public transport organizations with the objective of helping them successfully implement crowdsourcing activities. The paper is only a beginning; further research is needed on all aspects of how transport organizations can use crowdsourcing.

Figure 8 illustrates the companion website to this paper https://crowdsourced-transport.com giving an overview of the crowdsourcing structure (the author is currently working on a project to better define the fifth type of crowdsourcing: intentions, and therefore it is not shown on the website illustration).

Figure 8   Categorization of crowdsourcing in transport.

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