Smartphone App Evolution and Early Understanding from A Multimodal App User Survey

Susan Shaheen, Ph.D.
University of California, Berkeley
sshaheen@berkeley.edu

Adam Cohen, MCRP
University of California, Berkeley
apcohen@berkeley.edu

Elliot Martin, Ph.D.
University of California, Berkeley
elliot@berkeley.edu

Abstract

Travelers are increasingly turning to smartphone applications for an array of transportation functions. Four types of transportation apps have emerged: 1) mobility apps; 2) connected vehicle apps; 3) smart parking apps; and 4) courier network service (CNS) apps. This chapter discusses the history and trends leading to the growth and development of transportation apps and summarizes key characteristics of 83 transportation apps identified through an Internet search cataloging transportation apps with more than 10,000 downloads each. Seventy-one percent of the 83 apps identified incorporated a real-time data function (e.g., traffic conditions, roadway incidents, parking availability, and public transit wait times). Additionally, the chapter reports on findings from a survey, conducted in spring 2016, of 130 app users who downloaded the RideScout mobility aggregator app (which ceased operations in August 2016). The survey, was asked questions about their use of mobility aggregators more generally, sought to understand how multimodal information apps shift travel behavior. The findings showed that most users of such apps would walk, drive alone, and carpool during a typical month. Fifty percent of respondents drove alone once or more per day. Twenty-five percent owned one vehicle, and 75% owned two or more vehicles. Thirty-nine percent of respondents reported that they drove less or much less due to the apps. Findings from the survey suggest that multi-modal app users do change their travel behavior in response to information provided, and they may contribute to a reduction in vehicle use.

Introduction

Smartphones represent one of the most important transportation innovations of the 21st century. A variety of factors are changing the way people think about mobility including demographic shifts, advancements in geo-spatial routing and computing power, the use of cloud technologies, faster wireless networks capable of carrying greater bandwidth, congestion, and heightened awareness about the environment and climate change. Mobility consumers are increasingly using smartphone applications, dubbed "apps" for an array of transportation use cases. More people are starting their trips with smartphones to plan routes, seek departure information for the next bus or railcar, find a taxi via an e-Hail app, or source a private driver through services, such as Lyft or uberX. Factors driving transportation app growth include: time savings (e.g., high occupancy vehicle lanes available to users of dynamic ridesharing); financial savings (e.g., dynamic pricing providing discounts for peak and off-peak travel and for choosing low-volume routes); incentives (e.g., offering points, discounts, or lotteries); and gamification (e.g., use of game design elements in a non-game context) (Marczewski, 2012).

For mobility consumers, transportation apps offer instant access to real-time information previously unavailable (such as estimated departure and arrival times). This makes trip planning more convenient by aggregating modal and information feeds to provide users with a comparison of routes, departure times, and modal options. For public agencies, transportation apps can aid network management functions, such as disseminating roadway and public transportation information on incidents, delays, congestion, and service disruptions. Transportation apps enable mobility consumers to make more informed transportation decisions, which can aid public agencies in network management. This chapter includes five key sections. First, we provide an overview of the history and evolution of smartphone applications. Second, we present a synopsis of smartphone apps impacting transportation and results of our 2015 North American transportation app benchmarking analysis. Next, we present some behavioral understanding from a 2016 survey of 130 multi-modal app users. Fourth, challenges to the adoption and mainstreaming of transportation apps are discussed. Finally, we conclude with a summary of key findings.

History and Evolution of Smartphone Applications

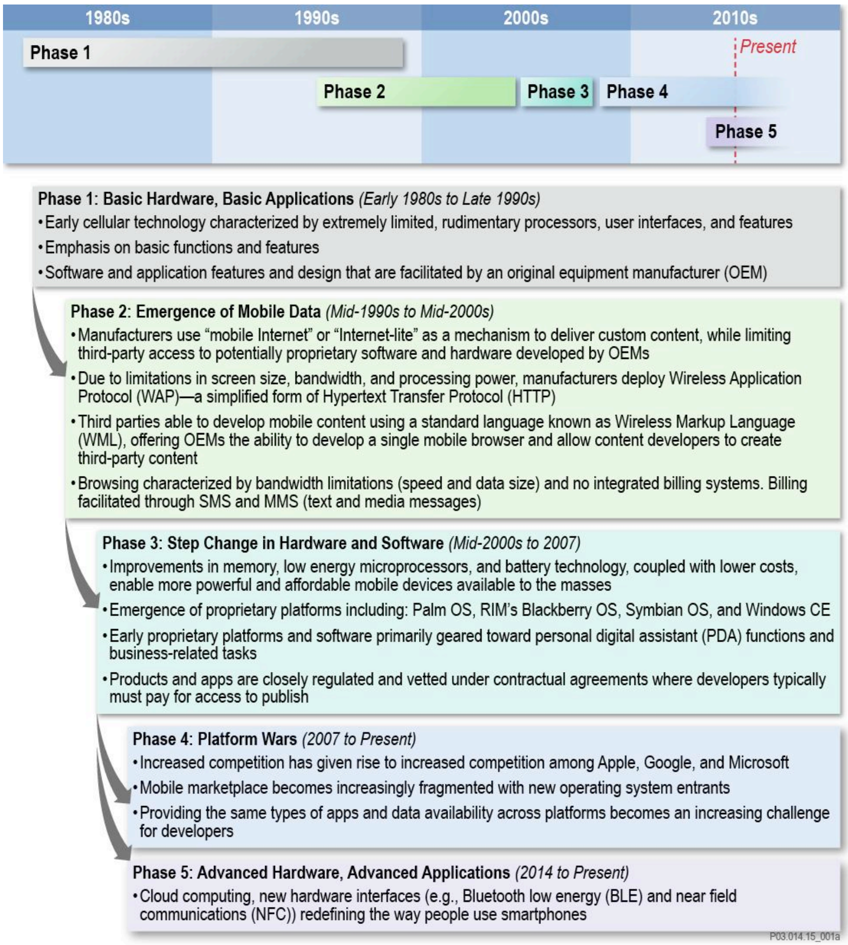
To understand how mobile apps have evolved and are impacting travel behavior, we discuss the history and trends leading to their growth and development. Smartphone apps have progressed through five key phases:

1. Basic Applications;

2. Wireless Application Protocol (WAP);

3. The Rise of Proprietary Platforms;
4. Platform Wars; and
5. The Rise of Multi-Platform Advanced Features.

These phases are summarized in Figure 1 below.



Source: (Shaheen et al. 2016)

Fig. 1. Five key phases in the evolution of smartphone apps

Phase 1: Basic Hardware and Applications: Early-1980s to Late-1990s

Mobile applications trace their origins to basic devices of the mid-1990s. These applications were extremely limited by rudimentary processors, simple user interfaces, and few features, almost entirely due to limited hardware capability. The Motorola DynaTac 8000X was the first commercially available cellular phone. First marketed in 1983, it had a talk time of about 30 minutes and retailed for approximately US$4,000, slightly less than a new car. The Motorola DynaTac placed calls and included a basic app to manage contacts (Clark, 2012). Early apps emphasized basic functions, such as arcade games, ring tone editors, calculators, and calendars. During Phase 1, software, application features, and design were facilitated by the original equipment manufacturers (OEMs). As cellular hardware began to advance, new multi-functional applications started to emerge. These developments began to change the way users viewed their phones, transforming them from a single-purpose calling device to a multi-purpose business tool and personal assistant as consumers increasingly requested more features (Clark, 2012).

Phase 2: Emergence of Mobile Data: Mid-1990s to the Mid-2000s

Beginning in the mid-1990s, equipment manufacturers started turning to the Internet to deliver mobile content while limiting third-party access to proprietary software and hardware developed by OEMs. Because early hardware was not directly compatible with the Internet due to limitations in screen size, bandwidth, and processing power, manufacturers developed the Wireless Application Protocol, known as WAP. WAP was a technical standard for accessing information over a cellular network and represented a lower bandwidth, which is a more simplified form of the hypertext transfer protocol (HTTP)--the foundation for the World Wide Web (Clark, 2012). WAP was designed to operate within the hardware and bandwidth limitations of cellular networks. WAP offered equipment manufacturers the ability to develop a single mobile browser and enabled developers to create third-party content. This set the stage for the development of third-party content, including future app marketplaces. However, the lack of a direct interface with HTTP, limited user interfaces, and technological limitations (screen size, bandwidth, etc.) were common criticisms of WAP (Clark, 2012). WAP browsers were notoriously known to be slow, tedious, and lacked an integrated billing system. Thus, early mobile payments had to be awkwardly facilitated through either Short Message Services (SMS – text messages) or Multimedia Messaging Services (MMS – a picture or multimedia messages). Additionally, users found it tedious to type on numeric keypads, and small screens resulted in content that was hard to read. Moreover, many users found it frustrating to load fragmented sentences and then wait for the next sentence fragment to download.

Broadly, the poor user experience, due largely to early technological (hardware and bandwidth) limitations, curbed commercial viability.

Phase 3: Step Change in Hardware and Software: Mid-2000s to 2007

Improvements in memory, microprocessors, and batteries coupled with lower hardware costs led to the development of more powerful mobile devices that could run more sophisticated operating systems, such as Windows and Linux. Most of these proprietary, "closed ecosystems" were regulated by the handset maker and/or operating system developer. Desktop computer developers, previously non-participants in mobile app development, could now create content for new devices (Clark, 2012). During this phase, a variety of proprietary platforms emerged including:

- *Palm Operating System (OS)* – A mobile operating system developed by Palm Inc. for personal digital assistants (PDAs) in 1996. Later versions were extended to support smartphones. As of 2008, there were 50,000 third-party applications for Palm OS (Treo and Centro 2006).

- *Blackberry OS* – A mobile operating system developed by Research In Motion (RIM), also known as BlackBerry Ltd. for its line of BlackBerry smartphones. BlackBerry OS was discontinued in January 2013.

- *Symbian OS* – A mobile operating system developed by Symbian Ltd. used on numerous basic mobile phones and smartphones produced by Motorola, Nokia, Samsung, and Sony Ericsson in the mid-2000s. In 2006, Symbian was estimated to have 73% of the market share of all smartphone operating systems (Litchfield 2007).

- *Windows CE* – A modular mobile operating system developed by Microsoft that was designed to support several types of devices, including smartphones. Originally released in 1996 (v. 1.0), the most recent version was issued in 2013 and will be supported through 2023.

These early proprietary platforms were primarily geared toward personal digital assistant (PDA) functions and business-related tasks.

In the late-1990s and early-2000s, mobile manufacturers began to bridge the gap between business-use mobile computing and cellular phones. In 1996, Nokia launched its communicator series meant to serve as a mobile phone and computer with facsimile (fax), email, text messaging, and web browsing functionality. Similarly, Microsoft's Pocket PC (later renamed Windows Mobile) was designed to mirror the experience of Windows XP, offering users a mobile start button. Pocket

PC/Windows Mobile was intended to bridge hardware gaps by operating on smartphones with touchscreens, mobile phones without touchscreens, and on PDAs with stylus functionality. These early hardware and software platforms laid the foundation for contemporary smartphone technologies but were often restricted by hardware, storage, and data bandwidth limitations.

Apple's launch of its iPhone in 2007, also represented a significant advancement in the user experience, as well as hardware and software. The iPhone quickly became the first mass-marketed smartphone device supporting third-party applications and cloud computing using a mobile broadband connection. Incorporating global navigation satellite systems (later coupled with assistance using cellular triangulation) allowed iPhone devices to quickly locate and lock onto satellite signals setting the stage for a variety of mobility functions. This changed not only how smartphones were used but also how users traveled. Another key development was full website compatibility on the iPhone. Websites no longer needed to be concerned with bandwidth limitations, special mobile sites, and protocols. Rather, full webpages could be readily displayed on a smartphone screen. This was critical in bridging the hardware and software digital divide that had previously limited the delivery of products and services to mobile users. iPhone's success was quickly replicated by Google's Android and an updated version of Windows Mobile, known as "Windows Phone."

With the advent of proprietary mobile platforms, developers and their apps became closely regulated and vetted under contractual agreements. Under this framework, developers began to pay to publish their apps to marketplaces. The marketplace model has often been criticized as limiting innovation, app availability, and compatibility across platforms, largely due to the lengthy app screening process for posting and updating apps.

Phase 4: Platform Wars: 2007 to Present

Increased competition has resulted in Phase 4 or "platform wars," evidenced by increased competition among Apple, Blackberry, Google, and Microsoft (Clark, 2012). As new OS entrants launch, the marketplace becomes increasingly fragmented. Developing and maintaining apps across multiple platforms becomes an increasing challenge for developers, particularly for individual developers and less resourced companies that cannot afford to develop application versions for multiple platforms. This lack of open-source standardization has created a complex and challenging marketplace for new entrants (entrepreneurs and developers) with limited resources to make their content available for all mobile users across a growing array of operating systems.

Phase 5: Advanced Hardware, Advanced Applications: 2014 to Present

New advanced hardware interfaces, including cloud computing, Bluetooth Low Energy (BLE)[1], and near field communications (NFC)[2], are changing the way people use mobile devices (Shaheen et al. 2016). These innovative technologies offer a number of practical uses for mobility functions (e.g., mobile fare payment and integration) and are changing how users interact with transportation apps. These trends include a variety of data sharing, aggregation and disaggregation, such as:

1. Wider, more integral use of data: Apps, such as Google Maps, aggregate disparate data feeds (traffic sensors, device satellite tracks, and self-reported roadway incidents) to provide more integrated and accurate predictions of user travel time (Shaheen et al. 2016);

2. Increased data sharing among services: Apps, such as Google Now, pull data from multiple sources. Third-party apps can provide summaries of important information from multiple apps and data sources. For example, a calendar app may integrate with a map app to display optimal trip routing (Shaheen et al. 2016);

3. Functional disaggregation: Apps are becoming less multi-functional and are instead focusing more on one or two key functions (Shaheen et al. 2016); and

4. Bundled apps as services: As data become more open and functions become more dispersed, new aggregator services—either new apps or native functions of operating systems—are creating innovative services, or "cards," from a grouping of apps. For example: a card notification on a smartphone informs

[1] *Bluetooth Low Energy (BLE):* With BLE, wireless transmitters, known as BLE beacons (approximately the size of a matchbox with a coverage radius measured in feet) send Bluetooth signals to smartphones and other Bluetooth-enabled mobile devices. BLE communicates with many users, allowing notifications for coupons, offers, and promotional information when entering the Bluetooth range. For example, a user walking past a bikesharing kiosk, public transit station, or a bus stop could be notified of bicycle availability, special rates, or the departure time of the next public transit vehicle. BLE also supports beacon-based navigation, which can assist in guiding users to destinations. San Francisco International Airport is using BLE-beacon technology to assist the visually impaired in navigating its terminals. BLE also supports mobile payment (Mogg, 2014).

[2] *Near Field Communications (NFC):* With NFC, smartphones communicate with postage-stamp sized NFC tags. NFC has a range of inches and communicates with a single user. NFC is best suited for settings requiring one-on-one secure data delivery. NFC can be used for mobile payment, transportation passes, and access cards (e.g., entering a carsharing vehicle).

the user of a new e-mail, allowing the user to quickly respond via e-mail or a texting app and to add an event to their calendar through the calendar app—all without opening a single dedicated app (Shaheen et al. 2016).

These trends are leading to a seamless, integrated, and narrowly tailored user experience. Many transportation apps are responding to these trends. For example, Lyft and uberX ridesourcing vehicles can be hailed from inside Google Maps, and delivery services are embedded into restaurant apps. In the future, app users can expect that the basic function of mode (or multimodal) selection to a destination involves a single app that is integrated with multiple, separate apps (routing, booking, payment, social media, and more) to deliver a personalized route recommendation, so the user is not burdened by referencing multiple apps. Together, this technological evolution is driving the development of new app-based services that will continue to impact the transportation sector.

Transportation Smartphone Apps

In this section, we define four key areas of transportation apps. We also present our U.S. smartphone transportation apps benchmarking analysis. To provide some context for this discussion, we present analysis from a 2015 *comScore* study of the U.S. smartphone market. This research estimates that Android has the largest mobile operating system market share, accounting for 53.2%, followed by Apple iOS at 41.3%. In contrast, Microsoft and BlackBerry each had 3.6% and 1.8% of the market share, respectively (Soomro, 2015). A limitation of the *comScore* study; nevertheless, is that it only reflects smartphone users. It excludes other mobile devices users (e.g., tablets, 2 in 1 notebooks, and wearable devices). While Microsoft Windows is widely recognized to have a small percentage of the smartphone marketplace, they have a relatively large mobile PC and tablet presence in the app marketplace. Further, it is important to note that in 2015, Windows 8 was phased out in anticipation of the Windows 10 Mobile release in the third quarter. Other mobile devices, such as wearable technology, tablets, and notebooks, can serve a transportation function but may have more limited app availability as many transportation apps are designed for smartphones. The increasing use of universal apps (single apps that can run on different size devices), such as Windows 10 universal apps, may expand the availability of transportation apps on a wider array of devices.

The main categories of transportation apps include: 1) mobility apps, 2) connected vehicle apps, 3) smart parking apps, and 4) courier network services (CNS) apps. There are also non-transportation apps that may impact the transportation network. Broadly, these apps are changing how people travel, interact with privately-owned automobiles and ship merchandise.

Mobility apps assist users in planning or understanding their transportation choices and may enhance access to alternative modes. Mobility apps can include a variety of apps including: 1) business-to-consumer sharing (e.g., carsharing, bikesharing); 2) peer-to-peer sharing (e.g., peer-to-peer carsharing, bikesharing); 3) mobility trackers (e.g., Moves); 4) apps for real-time public transportation information; 5) ridesourcing (e.g., uberX and Lyft); 6) e-Hail taxi apps (e.g., Flywheel); and 7) multi-modal trip aggregator apps (e.g., Swiftly, Moovit).

Connected vehicle apps allow remote access to a vehicle through an integrated electronic system. Generally, connected vehicle apps are designed for emergency situations (e.g., vehicle lockouts, dispatching assistance during an accident, etc.) and may also provide other vehicle services (e.g., diagnostic information, geolocating a vehicle, etc.). Many connected vehicle apps are developed by vehicle OEMs (e.g., General Motor's OnStar).

Smart parking apps provide information on the cost and availability of parking. Some smart parking apps may facilitate electronic payment. Generally, smart parking apps are paired with public or private parking systems or both (e.g., SFpark). Broadly, smart parking apps include *e-Parking* (apps that streamline the parking process and *e-Valet*, such as Luxe, (for-hire parking services used to dispatch valet drivers to pick-up, park, and return vehicles).

Courier network services (CNSs) provide for-hire delivery services for monetary compensation using an online application or platform (such as a website or smartphone app) to connect couriers using their personal vehicles, bicycles, or scooters with freight (e.g., packages, food).

Additionally, three categories of non-transportation apps that may impact the transportation network include: 1) Health Apps; 2) Environmental / Energy Consumption Apps; and 3) Insurance Apps. Health apps can assist users with monitoring their health (e.g., calories burned, heart rate, etc.) and changing their behavior (e.g., exercising more and eating less). Health apps can also be employed to help users understand the health impacts of their transportation choices (e.g., Map My Walk). Environment / Energy Consumption Apps track environmental impacts and the energy consumption of user behavior. These apps may predict a user's GHG consumption and may also include apps that encourage environmentally conscious behavior, such as eco-driving and eco-routing apps (e.g., Refill and greenMeter). Finally, insurance apps provide a variety of coverage and claims functions for users. These apps can also contain transportation functions, such as pay-per-mile automobile insurance (e.g., Metromile) and other usage-based pricing and incentives related to distance, travel time, and safe driving (e.g., Allstate's usage-based insurance app).

While transportation apps are readily available on app marketplaces, basic data benchmarks, such as the number of downloads, and usage characteristics, are often difficult to identify and catalog. For example, a walking app may be listed in the "health and fitness" category yet serve an important transportation function. Thus, one could miss a transportation-related app in such an analysis due to how apps are cataloged in a marketplace. Further, it is not possible to uniformly compare the number of downloads and user ratings across major app marketplaces. For instance, only the Google Play store publicly provides an approximate number of downloads, while the Apple's iTunes store alone distinguishes customer ratings among the current and earlier versions of an app. Finally, no marketplace has developed a metric to determine the frequency of app use (e.g., whether an app is downloaded a million times and used once or twice before it is uninstalled versus an app downloaded half as frequently but used daily on average). Consequently, it can be challenging to assess which apps have the greatest impacts on the transportation ecosystem.

2015 North American Transportation App Review

Between January and February 2015, we conducted a review of smartphone applications on four major North American app marketplaces (Apple, Blackberry, Google, and Microsoft). We excluded public transit agency apps from the review because many of these apps are available for direct download from public transit agency websites, which makes such apps more challenging to catalog due to the vast number of public transit agencies across North America. As part of this review, we benchmarked key qualitative functions among transportation apps with more than 10,000 total downloads. Key qualitative characteristics identified include: 1) operating system (OS), 2) real-time information availability, and 3) use of gamification and incentives.

Operating System

We identified 83 transportation apps across all four marketplaces that had 10,000 total downloads or more. We found that the majority of transportation apps were only available on Android and iOS, and frequently they were unavailable on Windows and Blackberry. As noted earlier, Windows 8 was being phased out at this time in anticipation of the Windows 10 Mobile release in Q3 of 2015.

Real-Time Data

We calculated that 86% and 80% of transportation apps were available on Android and iOS, compared to just 36% and 23% on Windows and Blackberry, respectively. Seventy-one percent of the 83 apps identified incorporated a real-time data function (e.g., traffic conditions, roadway incidents, parking availability, and public transit wait times).

Gamification

Gamification is the use of game theory and game mechanics in a mobile app to engage users. Apps that employ gamification configure the user as a "player" within a gamified app design. For example, the use of leaderboards, badges, levels, progress bars, and points are intended to encourage and/or discourage particular user behaviors (Herger, 2015; Marczewski, 2012). In a gamified context, app users may receive points, increased rankings, or other rewards for environmentally-conscious behaviors, such as carpooling or riding public transportation instead of driving alone. Particularly "bad" behaviors may be penalized by the loss of points or rankings, including driving alone on a "spare-the-air" day.

Gamification tends to leverage social aspects of competition to encourage socially and environmentally-preferable outcomes. Some of the most successful behavior change mechanisms pair gamification with social pressure. For example, the Waze and GasBuddy apps use competition and status seeking behaviors to encourage desired behavioral change. In this vein, gamification is often paired with incentives. Reporting roadway incidents and gas prices, in the case of each of these apps (respectively), can lead to the accumulation of points or statuses that can be redeemed for lottery entries, prizes, and leaderboard rankings to further increase gamified elements, competition, and social pressure. The urge to compete, rank highly, and conform to community norms can be a powerful motivational tool.

We found that 23% of the apps incorporate a gamified incentive, such as raffles or special badges (also known as favicons), symbolizing an achievement level. Some apps employ loyalty points that can be redeemed for rewards (e.g., discounts, gift cards, etc.). Loyalty points were the most common mechanism employed, accounting for approximately 21% of all incentives.

Gamification, social pressure, and incentives can be an effective way for apps to promote use and adoption, encourage certain types of transportation behaviors (e.g., ridesharing, cycling, etc.), and provide a mechanism for disbursing a variety of transportation demand management incentives. The user impacts of gamification and incentives in transportation apps have not been extensively studied and are not well understood.

Impacts of Multi-Modal Apps on Travel Behavior: 2016 Exploratory Survey of Multi-modal Transportation Information App Users

Multi-modal transportation information apps are smartphone apps that provide users with trip planning information on surrounding mobility options. RideScout was an example of an app that integrated an array of public and private transportation services. On August 3, 2016, RideScout ceased operations and the company transitioned to a different business model oriented toward mobile payments for travel. As an app, RideScout offered a single interface for users to compare transportation options (e.g., cost, mode, departure and journey time, etc.). Some of the services formerly integrated into RideScout's interface included: public transportation, ridesourcing, taxis, carpooling, ridematching, carsharing, bikesharing, scooter sharing, and eParking. In the summer of 2015, RideScout merged with GlobeSherpa and rebranded itself as Moovel, which is a public transit platform facilitating mobile ticketing and back-end transit agency operations. Moovel also offers an application programming interface (API), known as RideTap that allows third-party developers to integrate ridesharing, carsharing, bikesharing, and other transportation modes into a single interface.

In March 2016, the authors surveyed 130 people that had downloaded the RideScout app. We designed the survey to evaluate the attitudes and perceptions of respondents to apps like the RideScout mobile app, as well as evaluate the travel behavior and modal shift that might result from using multi-modal information apps. The population sampled included people who downloaded the RideScout app across the United States. It is important to note that we asked about the impacts of multi-modal apps more broadly and not specifically about RideScout. Hence, the impacts reported are not necessarily due to RideScout specifically but rather to multi-modal apps more generally. That is, those that downloaded RideScout were also users of other multi-modal apps, and their responses were given in the context of all such apps that they used. To recruit participants, RideScout sent an email on behalf of our study team with a survey link to an estimated 3,000 randomly selected users. This population consisted of those who had agreed in the summer of 2015 to be contacted by RideScout for future surveys. The sample contained 56.2% (73) male respondents, 42.3% (55) female respondents, with 1.5% (2) respondents declining to state their gender. Respondents were balanced toward younger ages, as 42% were between 24 and 36 years of age. Forty-six percent of respondents had completed a post-graduate degree program. Eighty-six of respondents were Caucasian/White, compared to 7% Asian, 5% Hispanic/Latino, and 4% African American. The remaining sample declined to provide their race/ethnicity (percentages do not add up to 100 because respondents could select more than one race/ethnicity). Finally, 72% of respondents earned more than $50,000 annually.

Nearly all respondents reported that they use transportation apps for multiple functions. The most common application was the use of mapping apps for driving, as 85% of respondents reported using transportation apps for this purpose. Other common applications included obtaining access to on-demand ride services (84%), obtaining information about public transportation services (77%), and receiving information about multi-modal transportation options (60%). Among those that used apps with multi-modal information, 22% used them every day and 66% reported using them at least once a week.

The survey contained questions that evaluated how use of multi-modal apps changed respondent travel behavior. Respondents were asked “How has your use of multi-modal transportation app(s) influenced your <use of mode X>…” where a number of modes were described in this context within separate questions. Fifty-eight percent reported that they did not change their driving behavior due to the availability of a multi-modal app. Of the respondent pool that did change their driving behavior, 38% stated they decreased their driving because of the multi-modal app in contrast to 4% that reported increasing it. Respondents generally reported shifts in travel behavior that led to less-energy intensive mobility. For example, 36% of respondents reported walking more versus 8% walking less. At the same time, 22% reported bicycling more, while only 5% reported bicycling less. For public transit modes, multi-modal apps seem to be even more beneficial. For urban rail, 43% reported that multi-modal apps increased their use of this mode, while only 8% said that they decreased their rail use as a result (the rest indicating no change). In the case of bus, 56% reported increasing their use, while 5% reported decreasing their bus use due to multi-modal apps. Respondents reported that emerging shared mobility options, such as Uber and Lyft, as well as one-way carsharing were positively influenced by the use of multi-modal apps. Forty percent increased their use of ridesourcing (e.g., Lyft, Uber) due to these apps versus only 8% of respondents reporting a decline. For one-way carsharing, 22% reported an increase, while only 4% reported using the mode less. Other modes, like commuter rail, also experienced a reported increase in use as aided by the multi-modal app. Round-trip carsharing experienced little change, positive or negative, due to multi-modal apps, while modes such as taxis, driving alone, and riding as a passenger in a car all had more respondents reporting a decrease versus an increase in use. The impact on taxi use was modestly negative, as 17% of respondents reported a decline in their taxi use, while 9% reported that the apps had increased their taxi use. Hence, the results suggest that multi-modal information apps more broadly are enabling people to use public transit and non-motorized modes more. Overall, the effect on shared mobility modes is more mixed, with ridesourcing and one-way carsharing benefiting the most from such apps.

Survey respondents also reported that obtaining real-time information about public transit arrivals, trip planning, and the convenience of having multiple modes in a single interface were the most common reasons for using multi-modal apps. Cost savings was rated as the least popular reason for using multi-modal apps. The top-rated reasons for not using a multi-modal app include: 1) users know in advance which mode they want to use, and 2) users do not like the uncertainty associated with real-time planning and mobility. Respondents were also asked about the impact of multi-modal apps on wait times, with 41% reporting a decrease in wait times, 6% reporting an increase, and the remaining sample reporting no change.

In summary, this early user survey suggests that mobility aggregators could have the potential to improve real-time information and convenience for app users, while reducing the frequency of vehicle use. Nevertheless, more research is needed with a larger sample and additional mobility aggregators to determine if these results are applicable to a wider user population.

Challenges and Opportunities for Adoption and Mainstreaming of App-Based Services

Despite the growing prevalence of transportation apps, some challenges impact the adoption and effectiveness of app-based transportation services. These challenges and opportunities include: 1) privacy challenges, 2) accessibility considerations, and 3) open data standards and data sharing.

Privacy policies for most apps, app marketplaces, software, and operating systems (e.g., Apple, Google) are often written in legalese making user agreements opaque, long, confusing, and difficult to understand for the vast majority of users. Apps, operating systems, and app marketplaces typically have multi-page user agreements with fine print that software companies "expect" users to read and consent. For the vast majority of users, this text is challenging to read on mobile devices. Many users may not understand what information they are consenting to share or are unaware of what private information they are exposing to third-parties through app use. Smartphone apps may intentionally or unintentionally collect a wide array of sensitive information, such as email addresses, phone numbers, financial and location information, and usage history of the apps installed on their phone and mobile browsing history. Location history may represent some of the most sensitive data collected and stored by transportation apps and shared with third parties to offer users additional products and services. Privacy and security concerns are complicated by this type of data sharing because this is often facilitated through third-party APIs[3], which may contain security vulnerabilities in addition to the cloud, software, and hardware security protocols. App developers, marketplaces, and OEMs have a continuing obligation to enhance security features and monitor their apps for potential security vulnerabilities. App marketplaces, in particular, play a critical role in ensuring that apps distributed on their sites are secure and free of malware.

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[3] An API, short for "Application Programming Interface" is a set of routines, protocols, and tools for building software and applications. APIs can help developers and smartphone apps share data and information between apps and make it easier for third parties to develop apps and incorporate features from existing apps.

In addition to privacy challenges, it is important that public agencies and app developers ensure accessibility for all users. Smartphones and data packages are often expensive (if not out of reach) of low-income individuals. Additionally, data availability and bandwidth speeds can limit smartphone app use in less urbanized and rural locations, which can also limit access.

Developers and public agencies interested in launching smartphone apps can address service quality and bandwidth limitations by allowing the caching of data when larger bandwidth is available and by designing “lite” versions of smartphone apps. Lite app versions and functionalities can provide users with a more functional and enjoyable user experience in times of lower bandwidth and poor data coverage. Additionally, app-based services that facilitate electronic payment may not be usable by unbanked users (e.g. users without a bank account or credit/debit card). Some of these apps may require fare payment via credit/debit cards or mobile/Internet banking. Unbanked users may find it challenging to use mobile apps requiring electronic fare payment. Public entities and app developers can address this challenge by allowing alternative payment methods in conjunction with paperless transactions or establishing programs that offer banking products and services for these users. Capital Bikeshare, for example, has established the “Bank On DC” program to assist prospective unbanked users open an account at local financial institutions. Finally, public agencies and app developers should give special consideration to users with special needs and ensure that disabled users have the ability to use all of the app features.

Public-private partnerships represent one of the greatest opportunities to enhance transportation access for all travelers. Fundamentally, smartphone apps can help to bridge an information divide and make multi-modal transportation more convenient, cost effective, and desirable by aggregating information and simplifying user choices. Offering open data allows public agencies and local governments to disseminate real-time transportation information to their communities, without the cost or responsibility of developing or maintaining their own smartphone apps. Establishing policies that facilitate real-time and static data sharing for APIs and other data is critical. Local governments can support data sharing by adopting acceptable use policies and developing terms and conditions for their data use. Efforts aimed at opening data and developing sharing standards will improve transparency and accessibility, while simultaneously encouraging the private sector to develop new features and apps that take advantage of these data feeds. Local governments and public agencies can meet future data needs by establishing a technology or data officer to manage the collection, sharing, and dissemination of transportation data, as well as the creation of a data dashboard to process and track travel behavior data.

Conclusion

Increasingly, mobility consumers are using smartphone applications (apps) for an array of transportation functions, such as vehicle routing, real-time data on congestion, information regarding roadway incidents and construction, parking availability, and real-time transit arrival predictions. Over the years, smartphone apps have evolved from early basic applications to apps with advanced features and functionality that is common today.

Four types of transportation apps have emerged: 1) mobility apps; 2) connected vehicle apps; 3) smart parking apps; and 4) courier network service (CNS) apps. In addition to these core transportation apps, a number of other apps can assist with transportation functions (e.g., health apps, environment and energy consumption apps, and insurance apps).

Findings from a user survey of 130 multi-modal app users showed that respondents are generally using public transit and non-motorized modes more in response to the information provided by the apps. They are also driving less, while the impact on shared mobility modes is mixed depending on the service. Thirty-eight percent of respondents indicated driving less or much less due to the apps. In addition, respondents reported that the apps facilitated reduced wait times. In the future, more research is needed with a larger sample and across a larger number of mobility aggregators to determine if these results are applicable to a wider user population. Additionally, more research is needed to understand user behavior in response to transportation apps and to fully understand their impacts on travel behavior choices, modal split, and other factors impacting transportation network.

Furthermore, public-private partnerships can help users overcome the information divide and make multi-modal transportation more convenient, cost effective, and desirable by aggregating information and simplifying user choices. Establishing policies that facilitate data sharing, adopting acceptable use policies, and developing terms and conditions for data use represent key opportunities for public-private collaboration.

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1.7 Full Authors' Information

Susan Shaheen, Ph.D.
Transportation Sustainability Research Center (TSRC)
University of California, Berkeley
408 McLaughlin Hall
Berkeley, CA 94720
USA
sshaheen@berkeley.edu

Adam Cohen, MCRP
Transportation Sustainability Research Center (TSRC)
University of California, Berkeley
1301 S. 46th Street, Bldg. 190
Richmond, CA 94804
USA
apcohen@berkeley.edu

Elliot Martin, Ph.D.
Transportation Sustainability Research Center (TSRC)
University of California, Berkeley
1301 S. 46th Street, Bldg. 190
Richmond, CA 94804
USA
elliot@berkeley.edu

2 Keywords

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