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Ridesharing in North America: Past, Present, and Future

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Ridesharing in North America: Past, Present, and Future

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ABSTRACT *Since the late 1990s, numerous ridematching programmes have integrated the Internet, mobile phones, and social networking into their services. Online ridematching systems are employing a range of new strategies to create "critical mass": (1) regional and large employer partnerships, (2) financial incentives, (3) social networking to younger populations, and (4) real-time ridematching services that employ "smartphones" and automated ridematching software. Enhanced casual carpooling approaches, which focus on "meeting places", are also being explored. Today, ridesharing represents approximately 8–11% of the transportation modal share in Canada and the USA, respectively. There are approximately 638 ridematching programmes in North America. Ridesharing's evolution can be categorized into five phases: (1) World War II car-sharing (or carpooling) clubs; (2) major responses to the 1970s energy crises; (3) early organized ridesharing schemes; (4) reliable ridesharing systems; and (5) technology-enabled ridematching. While ridesharing's future growth and direction are uncertain, the next decade is likely to include greater interoperability among services, technology integration, and stronger policy support. In light of growing concerns about climate change, congestion, and oil dependency, more research is needed to better understand ridesharing's impacts on infrastructure, congestion, and energy/emissions.*

Introduction

Increasingly, ridesharing is being discussed as a powerful strategy to reduce congestion, emissions, and fossil fuel dependency. It is the grouping of travellers into common trips by car or van. It is also widely known in the UK as liftsharing and car sharing (this should not be confused with the terms "carsharing" in North America, and "car-sharing" or "car clubs" in the UK, which refer to short-term auto use; Shaheen *et al.*, 2009). Ridesharing differs from for-profit taxis and jitneys in its financial motivation. When a ridesharing payment is collected, it partially covers the driver's cost. It is not intended to result in a financial gain. Moreover, the driver has a common origin and/or destination with the passengers.

Ridesharing's modal share has declined since the 1970s in the USA. In 1970, 20.4% of American workers commuted to work by carpool, according

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to the US Census. This has declined to 10.7% in 2008 (US Census Bureau, 2008). The largest drop occurred between 1980 and 1990, when carpooling declined from 19.7% to 13.4%. A drop in gasoline prices, as well as improved fuel economy and shifting social trends, contributed to this decline (Ferguson, 1997).

However, ridesharing has increased slightly in recent years. From a low of 10.1% in 2004, carpooling has risen slightly and settled around 10.7% since 2005 (US Census Bureau, 2004, 2005). Similarly, ridesharing has increased somewhat since 2001 in Canada. Approximately 7% of Canadian workers commuted as a passenger in 2001; this increased to 7.7% in 2006 (Statistics Canada, 2008). Interestingly, there are seven times as many US passenger-miles for commute trips by carpool and vanpool as there are for public transit (C. Burbank, personal communication, 15 November 2009).

In this paper, the authors explore the past, present, and future of ridesharing in North America. The study approach included a literature review, an extensive Internet search for all major ridesharing programmes operating in North America today, and interviews with a broad range of ridesharing experts (designated throughout the paper as "personal communication"). This paper is organized into five sections. First, the authors define and classify ridesharing, as well as discuss its benefits and barriers. Next, ridesharing's history in North America is described with a focus on the first four phases. The third section explores the fifth phase: current ridesharing programs. Ridesharing's future is explored in the fourth section. Finally, the authors conclude with a summary and recommendations for future research.

Background

Ridesharing typically includes carpooling and vanpooling. Carpooling involves grouping travellers into a private automobile, while vanpooling entails individuals sharing a ride in a van. Ridesharing also includes more unique forms, such as casual carpooling. Since the authors define ridesharing as non-profit, with similar origins and/or destinations for both driver and passenger, cab sharing, taxis, and jitneys are not included.

In Figure 1, the authors propose a ridesharing classification scheme. This classification is based on how ridesharing appears today and the relationship among its participants. The "acquaintance-based" carpool is typically formed among families and friends, often called "fampools", as well as among co-workers. Next, the "organization-based" division refers to carpools and vanpools that require participants to join the service whether through formal membership or simply visiting the organization's website. The term does not necessarily refer to consistent participation in the same carpool or vanpool every day, as some schemes allow for varying carpool participants. Vanpools are categorized into four types, depending on how the vanpool is owned and operated (Winters and Cleland, undated). Finally, "*ad hoc*" ridesharing requires little relationship between participants and does not include membership. *Ad hoc* ridesharing is realized through casual carpooling. The last division is based upon the mechanism that organizes the shared rides. This includes self-organization, incentives, notice boards, and various computerized ridematching products.

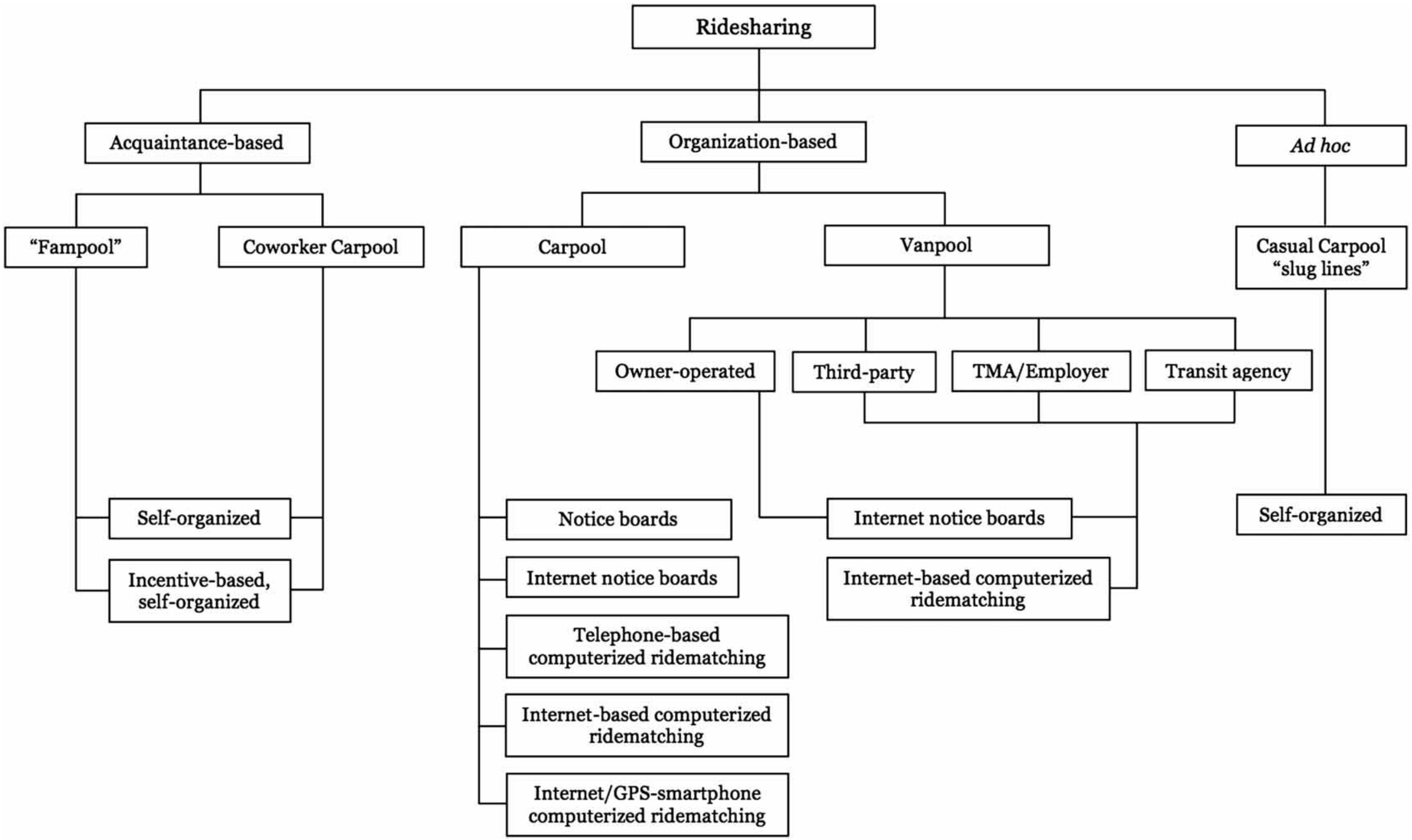

Figure 1. Ridesharing classification scheme.

Since ridesharing reduces the number of automobiles needed by travellers, it claims numerous societal benefits. Noland *et al*. (2006) assert that enacting policies to increase carpooling is the most effective strategy to reduce energy consumption besides prohibiting driving. Other benefits include reduced emissions, traffic congestion, and parking infrastructure demand; however, the magnitude of such benefits is unclear. The SMART 2020 report estimates that employing information and communications technology (ICT) to optimize the logistics of individual road transport could abate 70 to 190 million metric tons of carbon dioxide emissions (Global e-Sustainability Initiative, 2008). Using social networking to match travellers together for carpools and vanpools is one ICT strategy.

On an individual level, the benefits are more tangible. Carpool and vanpool participants experience cost savings due to shared travel costs, travel-time savings by employing high-occupancy vehicle (HOV) lanes, and reduced commute stress, particularly for those with longer commute distances. In addition, they often have access to preferential parking and additional incentives.

Despite its many benefits, there are numerous behavioural barriers to increased ridesharing use. An early study of attitudes towards carpooling found that individuals often see the attractiveness of carpooling but are disinclined to sacrifice the flexibility and convenience of the private automobile (Dueker and Levin, 1976). Moreover, psychological factors, such as the desire for personal space and time and an aversion to social situations, can impact ridesharing adoption (Bonsall *et al*., 1984). Personal security is also a concern when sharing a ride with strangers, although this is a perceived risk (M. Oliphant, personal communication, 15 July 2010).

Carpooling is often referred to as the "invisible mode", because it is difficult to observe, study, and champion (P. Minett, personal communication, 22 July 2010; P. Winters, personal communication, 22 July 2010). There is little systematic documentation of carpooling's history and few quantitative data, simply because carpools are difficult to record and count.

History of North American ridesharing

In this section, the authors provide an overview of ridesharing's history, focusing on the commute segment. North American ridesharing's evolution can be categorized into five key phases: (1) World War II car-sharing clubs (1942–45); (2) major responses to energy crises (late 1960s to 1980); (3) early organized ridesharing schemes (1980–97); (4) reliable ridesharing systems (1999–2004); and (5) technology-enabled ridematching (2004 to present). Jitneys of the 1910s are not included in this paper because there is no evidence that they directly gave rise to ridesharing. Each of the five ridesharing phases is summarized in Figure 2. Table 1 provides a glossary of ridesharing terms, which are used throughout this paper. Table 2 summarizes lessons learned.

Phase one: car-sharing clubs (1942–45)

Ridesharing began during World War II through "car clubs" or "car-sharing clubs". A 1942 US government regulation required that ridesharing arrangements to workplaces be made when no other alternative transportation means were available (Columbia Law Review, 1942). The US Office of Civilian

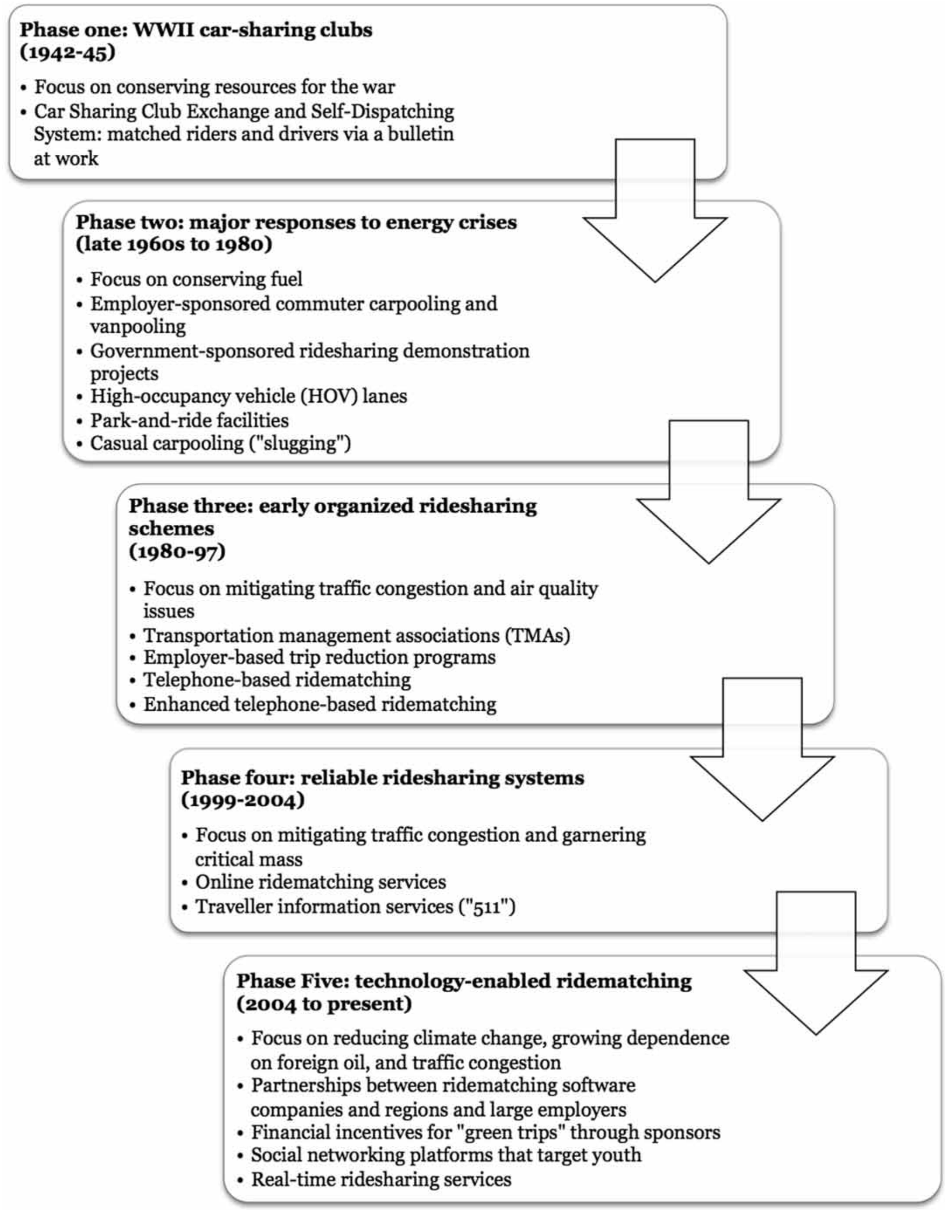

Figure 2. Five phases of North American ridesharing.

Defense asked neighbourhood councils to encourage four workers to share a ride in one car to conserve rubber for the war effort. It also created a ridesharing programme called the Car Sharing Club Exchange and Self-Dispatching System (OCD, 1942). A precursor to today's Internet notice boards, this system matched riders and drivers via a bulletin board at work. Factories and companies were responsible for forming these car-sharing clubs. Even churches, homemakers, and parent–teacher associations were responsible for forming carpools to and from various functions.

Table 1. Glossary of key ridesharing terms.

Ridesharing term	Description
Car-sharing clubs	The US government organized the first ridesharing schemes during World War II. They were used to promote ridesharing as a way to conserve resources for the war effort.
Vanpooling	Vanpooling is ridesharing on a larger scale than carpooling, which occurs in a large van. Vanpools are used by commuters travelling to a common employment centre and are almost always prearranged. There are currently no known dynamic vanpooling programmes (MIT Real-Time Ridesharing Research, 2009). Participants share operating costs. Often, vanpools are partially subsidized by employers or public agencies, further lowering commuting costs.
HOV lanes	These are special lanes reserved for use by buses and automobiles with typically two or more (sometimes three or more) occupants. They are built to encourage and facilitate public transit and ridesharing, including vanpools and casual carpools.
Casual carpooling (also known as "slugging")	Casual carpools are a user run, informal form of *ad hoc* ridesharing. This involves the formation of impromptu carpools of typically three or more commuters per vehicle: one driver and two or more passengers. Carpools form during morning commute hours at park-and-ride facilities or public transit centres and take advantage of existing HOV lanes to get to a common employment centre. Carpools also form during the evening commute but usually on a smaller scale.
Park-and-ride facilities (also known as carpool parking lots)	These are parking lots for commuters to park personal vehicles and then use public transit or ridesharing for the remainder of the journey to work. There are two types in North America: (1) lots situated at suburban commuter rail stations to encourage public transit use and (2) lots located by freeway entrances in suburban areas ("fringe" or "remote park-and-ride facilities") to encourage ridesharing and bus use. The authors focus on the latter type.
TMAs	TMAs are voluntary organizations formed by large employers, developers, and local politicians to address local transportation and air quality issues. They are typically non-profit and represent the private sector's involvement in transportation demand management strategies. TMAs promote a wide range of transportation options as an alternative to solo driving and often manage the region's carpooling and vanpooling programmes.
EBTR programmes	An EBTR programme is often a type of TRO requiring employers to reduce the number of employees driving to work alone. Ridesharing programmes are often used to comply with such an ordinance. They are also implemented to mitigate traffic congestion, air quality concerns, or both.

(*Continued*)

Table 1. Continued

Ridesharing term	Description
Telephone-based ridematching	This is the earliest form of "dynamic ridesharing". This approach allows users to request rides, offer rides, and receive ridematching information in real time over the telephone. Either human operators or an automated interface communicates with users. "Enhanced" telephone-based ridematching includes capabilities such as: Internet, e-mail, mobile phone, personal digital assistants, and GIS.
Online ridematching programmes and platforms	This approach entails Internet-based computerized ridematching, which employs GIS technology to match potential users travelling to and from similar places. Some software companies have developed ridematching "platforms"—a suite of services that a public agency or employer could purchase for a monthly fee.
Traveller information services ("511")	These are telephone hotlines (with the telephone code "511") for traveller information dissemination. The traveller information provided differs by region; it may include traffic and weather conditions, road construction and closures, public transit schedules, and ridesharing information.
Real-time ridesharing	These services use GIS and global positioning system technologies on Internet-enabled "smartphones" to organize ridesharing in real time, just minutes before the trip takes place. Drivers post their trip as they drive, and potential riders request rides right before their desired departure time. Ridematching software automatically matches riders to drivers with similar trips and notifies each party's smartphone.

Phase two: major responses to energy crises (late 1960s to 1980)

Ridesharing reappeared in the late 1960s and grew significantly in the 1970s in response to the energy crisis and the Arab oil embargo of 1973 to 1974 (Pratsch, 1979; Weiner, 1999). During phase two, strategies to facilitate ridesharing included: employer-sponsored commuter ridematching programmes, vanpooling, HOV lanes, casual carpooling, and park-and-ride facilities.

Employer-sponsored commuter ridematching programmes. Ridesharing resurfaced in the late 1960s and early 1970s at major employment sites. Large-scale employers, challenged with managing congestion and office parking supply, turned to commuter ridematching programmes. These programmes were created relatively simply—each company collected employee data, hand-matched those who were neighbours (this eventually became computerized), and distributed personalized matches (Pratsch, 1975). This straightforward method proved highly successful; when coupled with priority parking privileges, several companies were able to double vehicle occupancies and reduce parking lot strain (Pratsch, 1979).

Beginning in 1973, the Arab oil embargo shifted ridesharing's focus from constrained parking supply concerns to energy conservation. Employer-sponsored commuter ridematching programmes caught the attention of US federal agencies as an aggressive tool to achieve energy conservation goals (Pratsch, 1979). The Federal Highway Administration (FHWA) began cataloguing successful

Table 2. Lessons learned from ridesharing's past

HOV lanes: The characteristics of a successful HOV facility are (1) enough HOVs using the facility to move more people than mixed-use lanes and to appear full enough to gain public acceptance; (2) travel-time savings over mixed-use lanes; (3) an increase in the number of people moved through the corridor; (4) evidence that the facility impacts travel mode choice; and (5) compliance with facility rules (Schijns, 2006).A successful HOV lane network requires regional coordination and integration, enforcement of lane rules, long-term monitoring, and effective marketing for public awareness (Transport Canada, 2007).
Vanpooling: There have been many studies on vanpools and its participants to assess benefits and understanding. A 1991 vanpool survey in Los Angeles found that riders benefited from increased travel speeds (37.4 mph or 60.2 km/h, as opposed to 30 mph or 48.3 km/h driving alone) and reduced commute costs (US$0.06/mi as opposed to US$0.20/mi driving alone) (Kumar and Moilov, 1991). A 2004 survey argued that because of this, successful marketing to potential vanpoolers should highlight time and cost savings and reduced commute stress. Moreover, incentive programmes are important for lowering costs, which is a barrier to first-time participants (RIDES for Bay Area Commuters, 2004). Key lessons learned from operating a public vanpool programme include minimizing costs and providing excellent customer service, particularly when riders are paying most of the cost (S. Pawlowski, personal communication, 27 July 2010). A public transit agency vanpool programme can keep costs down by subcontracting vehicle maintenance and properly assessing whether to purchase or lease vans (P. Woodworth, personal communication, 27 July 2010).
Casual carpooling: For casual carpooling to be successful, there should be: (1) a time savings incentive for drivers; (2) monetary savings for passengers; (3) pick-up locations near freeways, residences, parking, or public transit stops; (4) a common drop-off location; (5) convenient public transit for the evening commute; and (6) an HOV requirement of three or more persons to ease personal safety concerns (Beroldo, 1990; Reno *et al*., 1989).
Park-and-ride facilities: Several lessons can be applied to future plans for park-and-ride facilities. A park-and-ride network should be comprehensive and well documented, focusing on transportation system connectivity, future infrastructure investments, and other needs for the surrounding communities. Moreover, each facility should be safe, well lit, and comfortable. Those near capacity must discover ways to increase parking supply without compromising cleanliness and security (Shirgaokar and Deakin, 2005; Spillar, 1997).
EBTR programmes: There are several lessons to be learned from past mandatory EBTR programmes: (1) the problem to be addressed must be clearly defined, (2) all parties much be involved, (3) reasonable targets (4–6% VMT reduction) should be established and phased in over time, and (4) costs and benefits must be fully analysed and monitored (Dill, 1998). Specific best strategies remain limited due to lack of detailed descriptions of past incentives used. However, 67% of Regulation XV EBTR programmes employed preferential parking for carpools and vanpools (Giuliano *et al*., 1993).
Telephone-based ridematching: A 1996 study amassed several lessons from the preliminary Smart Traveler programmes. There is resistance to telephone-based ridematching, as most workers carpool with co-workers they already know. Moreover, highly technical systems require frequent monitoring to ensure usability. Finally, users must understand a programme's services (e.g. one-time matching rather than regular carpooling) (Golob and Giuliano, 1998).
Traveller information services: A major lesson of traveller information services is that uniform "511" branding across North America helped consumers remember and easily access the service (D. Lively, personal communication, 20 July 2010). Further, a "511" ridesharing option must be easily accessible to be well used.

employer ridematching programmes to publish guidebooks on carpooling and vanpooling. FHWA conducted a nationwide survey of ridematching programmes, many of which began during the energy crisis. The study found an increase of 29 400 commuters in carpools and a reduction of 23% of vehicle-miles travelled (VMT) among 197 000 employees (Pratsch, 1975). Observing this success, the

1974 Emergency Highway Energy Conservation Act provided federal highway funds for 106 carpool demonstration programmes in 96 US metropolitan areas through 1977 (Wagner, 1978). The US Department of Transportation (USDOT) then established the National Ride-Sharing Demonstration Program in March 1979, with the objective of increasing ridesharing use by 5% (Weiner, 1999).

Vanpooling. Vanpoooling was another aspect of employer-sponsored ridematching programmes, which grew in use during the 1970s. The first employer-sponsored vanpool programme began April 1973, with the "3M Commute-A-Van" pilot programme. The Federal-Aid Highway Act of 1976 also spurred vanpooling growth. That same year, the National Association of Van Pool Operators was formed (Kircher and Wapensky, 1978).

There are four types of vanpools. First, there are owner-operated vanpools, which are privately managed by individuals who typically own or lease the van and organize the ride arrangements. Second, there are Transportation Management Associations (TMAs)/employer vanpools that are sponsored for employees to commute to and from a common employment centre. TMAs often work with employers to assist and provide incentives to vanpoolers. Third, there are public transit agency vanpools, which are used to supplement the region's existing bus system. Finally, companies lease vans to employers or groups of commuters, providing insurance and ridematching to form third-party vanpools.

HOV lanes. The first HOV lanes opened in 1969 along the Shirley Highway (I-395) in Northern Virginia and Washington, DC (Chang *et al*., 2008). Since then, regions across the USA and Canada have built extensive HOV lane networks. As of 2008, there were 345 HOV facilities in the USA, with over 2300 directional lane-miles (Chang *et al*., 2008; Metro, 2010). As of 2007, Canada had 35 facilities with approximately 280 lane-kilometres (174 lane-miles) (Transport Canada, 2007).

Casual carpooling. Casual carpooling—also known as "slugging"—began during the 1970s and exists today on a large scale in three US metropolitan areas: Houston, Texas; Washington, DC, and Northern Virginia; and the San Francisco Bay Area. As of 2007, Houston's "slug lines" have 900 daily participants (Minett and Pierce, 2010). As of 2006, Washington, DC's slug lines attract 6459 daily participants (VanasseHangenBrustlin, 2006). As of 1998, the San Francisco Bay Area has 8000 to 10 000 daily participants (Minett and Pierce, 2010).

Slug lines between Northern Virginia and Washington, DC, began around 1975 in response to the Arab oil embargo and the recently constructed Shirley Highway (I-395) HOV lanes (Oliphant, 2008). At that time, minimum vehicle occupancy was four, so drivers without enough passengers would drive to a bus stop and offer rides to bus riders as a way to meet HOV requirements. Today, Washington, DC's system has about 25 pick-up locations and destinations (Forel Publishing Company, 2010).

Casual carpooling exists in the San Francisco Bay Area between communities east and north of the San Francisco Bay and downtown San Francisco. It began in the 1970s partially due to public transit fare increases and service disruptions (Beroldo, 1990). Casual carpooling has grown due to the HOV lane on I-80 and the HOV/bus-only bypass at the San Francisco-Oakland Bay Bridge toll plaza (Beroldo, 1999). Today, the system has approximately 24 morning pick-up locations (Ride Now, 2010).

Several casual carpooling surveys have been conducted to study this phenomenon; they found significant driver travel-time savings and passenger cost savings were the main reasons for participation (Maltzman, 1987; Reno *et al*., 1989; Beroldo, 1990, 1999; Burris and Winn, 2006). A legitimate concern for public agencies is the impact of casual carpooling on existing traffic and public transit ridership. Past Bay Area studies estimated the impact on Bay Bridge traffic ranged from 89 cars removed from the road to 645 cars added (Beroldo, 1990, 1999). Differing methodologies led to such a wide difference in traffic impact, depending on critical assumptions made regarding the probability of a modal shift, if casual carpooling were unavailable to each traveller. Thus, casual carpooling's effect on congestion and public transit ridership is still unclear.

Park-and-ride facilities. Park-and-ride facilities began in the USA in the 1930s as impromptu parking along bus routes (Bullard and Christiansen, 1983). Remote park-and-ride facilities began to gain interest from planning agencies in the late 1960s. Subsequently, the Federal Aid Highway Act of 1968 authorized federal funding for demonstration projects, such as remote park-and-ride facilities. The first of such was built in Woodbridge, New Jersey (Noel, 1988). Today, California has the largest remote park-and-ride lot capacities in the USA. As of July 2010, there were 327 park-and-ride facilities run by the California Department of Transportation (Caltrans), with 33 889 parking spaces (Caltrans, 2010).

Remote park-and-ride facilities in Canada were first started in the 1970s in the Province of Ontario. The Ontario Ministry of Transportation (MTO) developed a Travel Demand Management Strategy, which included carpool lots, HOV lanes, and ridesharing. During the 1970s, illegal and unsafe parking near freeways began raising concern. MTO opened its first carpool lot in 1979, providing safe, legal parking for carpooling commuters (Gan *et al*., 1998). Today, MTO runs the largest system in Canada, with 80 carpool lots and 5671 spaces (MTO, 2010).

Park-and-ride facilities are considered to be a critical component for promoting ridesharing in a region. A Bay Area study found that 59% of park-and-ride commuters formed prearranged and casual carpools at facilities that were near HOV lanes or inadequately served by public transit (Shirgaokar and Deakin, 2005).

Phase three: early organized ridesharing schemes (1980–97)

As energy conservation efforts waned in the 1980s and 1990s, transportation demand management shifted focus to improving congestion and air quality issues. Advances in computerized ridematching during this period also marked a move towards more dynamic ridesharing applications in the form of telephone- and Internet-based ridematching programmes. However, as gasoline prices returned to lower levels during this time, ridesharing lost much of its competitiveness. Many of the early schemes, with developing and imperfect technology, never gained much use but formed the basis for many of today's ridesharing services.

Employer-based trip reduction programmes. Ridesharing programmes in the 1980s shifted focus back to reducing traffic congestion in suburban office parks—a similar issue was addressed in the late 1960s. These suburbs began using trip reduction ordinances (TROs) to encourage commute alternatives to driving alone. One type of ridesharing TRO was the mandatory EBTR programme; one of the first was launched in Pleasanton, California, in 1984 (Dill, 1998). This

TRO limited peak-hour solo driving to no more than 55% of the daytime workforce. Employers with 100 or more employees were required to meet this standard by any means, including ridesharing. Pleasanton's TRO resulted in moderate increases carpooling and vanpooling.

Air quality districts began implementing similar EBTR programmes. On 1 July 1988, the Southern California Air Quality Management District (SCAQMD) began implementing Regulation XV, the largest mandatory EBTR programme in the USA—affecting over 2.26 million employees or 40% of SCAQMD's 5.4 million workers (Giuliano *et al.*, 1993; Dill, 1998). Its goal was to achieve National Ambient Air Quality Standards by 2010, requiring employers to meet a minimum average vehicle ridership (AVR) of 1.5 for most of the urban and suburban region (Dill, 1998).

On the state level, the California Clean Air Act was passed in 1988, requiring regions to create plans to manage air quality. One strategy employed was an EBTR programme similar to that of SCAQMD. On a federal level, the Federal Clean Air Act of 1990 required regions with serious and extreme ozone non-attainment to implement an EBTR programme (Dill, 1998).

By the early 1990s, opposition to EBTR programmes was increasing. First, Regulation XV was unable to achieve its AVR goals. California then passed Senate Bill 437 in 1995, prohibiting any agency from mandating EBTR programmes. On the federal level, H.R. 325 also passed in 1995, which allows states to use programmes other than EBTR to reduce emissions. Soon after, SCAQMD changed its focus from reducing trips to reducing emissions and eliminated Regulation XV (Dill, 1998).

A major issue with past mandatory EBTR programmes was the lack of monitoring and assessment. Very few programmes estimated reductions in VMT or greenhouse gas emissions on either a local or regional level. A 2010 policy brief estimated that EBTR programmes can reduce commute VMT for a workplace or on regional scale between 4% and 6% (Boarnet *et al.*, 2010).

Telephone-based ridematching. During the 1990s, several cities began telephone-based ridematching programmes. The University of Washington alongside the Bellevue Transportation Management Agency conducted the "Bellevue Smart Traveler" pilot from November 1993 to April 1994. Los Angeles's Commuter Transportation Services tested the "Los Angeles Smart Traveler" programme from July to September 1994; the pilot was limited to the 68 000 people affected by the 1994 Northridge Earthquake (Haselkorn *et al.*, 1995). Sacramento Rideshare also conducted a field operational test of "Rideshare Express" from 1994 to 1995 (Casey *et al.*, 1996). Rideshare Express interfaced with users through human operators, while Bellevue Smart Traveler and Los Angeles Smart Traveler used an automated interface.

The programmes were deemed unsuccessful due to low use. Bellevue Smart Traveler only had six logged ridematches (Haselkorn *et al.*, 1995). Los Angeles Smart Traveler had an average of 34 weekly users, with only a 20% chance of a successful ridematch (Golob and Giuliano, 1998; Loukakos and Picado, 2000). Rideshare Express received 10–15 match requests, but it did not provide any successful match (Kowshik *et al.*, 1996). Only the Los Angeles programme had available operational cost data; the one-year programme averaged $110 per call (Golob and Giuliano, 1998). It can be inferred from the low usage, that high cost was a key programme issue.

Enhanced telephone-based ridematching. After the telephone-based pilots failed, several "enhanced" programmes were proposed, that included new and developing technologies. The University of Washington launched the "Seattle Smart Traveler" pilot from March 1996 to May 1997 (Dailey *et al*., 1999). This programme added Internet and e-mail capabilities, resulting in 500 ride requests and 150 potential ridematches (Casey *et al*., 1996). It was more successful than its Smart Traveler predecessors due to its closed environment; it was open only to faculty, staff, and students of the University of Washington (Levofsky and Greenberg, 2001). Alleviating personal security concerns alongside strict on-campus parking restrictions also helped garner more users.

Two other enhanced programmes, ATHENA and MINERVA, also were proposed but did not progress beyond the developmental stage. The Federal Transit Administration (FTA) and the City of Ontario, California, began developing the ATHENA Smart Traveler programme between 1994 and 1996. ATHENA's ridematching and user interface were completely computerized, employing mobile phones and PDAs with geographic information system (GIS) technologies to identify and record users and trips. MINERVA built upon ATHENA, adding online services, such as online banking and shopping to reduce errand trips. Neither system was implemented—ATHENA was cancelled due to a city council turnover, and MINERVA evolved into a FTA study on microbus services (Levofsky and Greenberg, 2001; Woodworth and Behnke, 2006). However, the Internet and GIS components of these initiatives formed the basis of many ridesharing programmes used today.

Phase four: reliable ridesharing systems (1999–2004)

With most dynamic ridematching applications of the 1980s and 90s failing to overcome the "critical mass" barrier (i.e. providing enough users to consistently create a successful instant ridesharing match), most North American ridesharing systems between 1999 and 2004 focused on systems to encourage ridesharing among commuters who had the most reliable trip schedules. This included online ridematching and traveller information services.

Initial online ridematching services. With the proliferation of the Internet, many ridesharing systems took online forms, known as online ridematching. Full-fledged, online ridematching services began around 1999. Before then, websites were either simple pages listing agency contact information, online forms for users to e-mail the agency to receive a matchlist, or online notice boards for users to manually post or search carpool listings (Bower, 2004). Since 1999, private software companies began developing ridematching "platforms", providing their suite of services to clients for a monthly fee.

Carpools formed through online ridematching tended to be more static and inflexible and required prearrangement. While it was easier to find ridematches in a larger online database, these carpools still suffered from the same drawbacks as traditional carpools; namely, regular commuters lost the flexibility that private auto travel offered. As housing and employment centres became more dispersed, giving even less incentive to rideshare, online ridematching had difficulty gaining more users than its related employer-sponsored commuter ridematching programmes of the late 1960s. Consequently, online ridematching programmes were best suited for commuters with similar, regular schedules.

Traveller information services ("511"). In the 1990s, over 300 telephone numbers for traveller information were used in the USA (FHWA, 2008). On July 21, 2000, the Federal Communications Commission designated "511" as the traveller information telephone number available for local, regional, and state agencies to use across the USA (FHWA, 2009). Canada had similar plans for a uniform traveller information telephone hotline. The first 511 service in Canada began in Nova Scotia in January 2008 (Lombardi, 2008).

As of January 2009, 43 "511" services were available in 35 states to over 150 million Americans (FTA, 2009). Four services were accessible in four provinces in Canada, as of December 2009 (CBC News, 2009). Only 13 USA "511" services had a carpool and/or vanpool information option (FTA, 2009). Québec "511" was the only Canadian service with a ridesharing option.

Lessons learned

Table 2 describes the key lessons learned from various ridesharing strategies in the past. These lessons have built a foundation for ridesharing systems today.

North American ridesharing: the present

In this section, the authors focus on ridesharing activities from 2004 to the present. This period encompasses the fifth ridesharing phase, called: "technology-enabled ridematching". While this period continues to include casual carpooling, HOV lanes, and park-and-ride ridesharing efforts, it is most notable for the widespread integration of the Internet, mobile phones, and social networking (i.e. an online community where individuals connect and interact) into ridesharing services. At present, the majority of North American ridematching services use online websites as their chief technology medium. Many of them are based on a ridesharing software platform purchased from a private company. As of July 2011, there were approximately 12 such companies in North America that offer this software (e.g. Ecology and Environment, Inc. offers GreenRide®, and Pathway Intelligence Inc. provides Jack Bell Ride-Share). While the abundance of online ridesharing systems is promising, it has resulted in disparate, non-standardized databases that leave many programmes with a lack of critical mass. Four key developments characterize the present and aim to address the common ridesharing concerns of critical mass, safety, or both.

Ridematching platform partnerships

From 2004 to the present, a new generation of ridematching platforms has been developed for regions and employers to use. Moreover, there has been significant growth and overall success with this strategy. Partnerships between ridematching software companies and its large-scale clients take advantage of existing common destinations and large numbers of potential members. These firms sell their ridematching software "platforms" to public agencies and employers, which are sometimes used as standalone websites for each group. While this partnership strategy has gained more users than previous ridesharing phases, it is most suited for commuters with regular schedules.

"Green trip"-sponsored incentives

Many public agencies and companies promote ridesharing by providing its members with incentives. One example is NuRide—an online ridesharing club with over 63 000 members in seven US metropolitan areas (NuRide, 2011). NuRide rewards points when members carpool, vanpool, take public transit, bike, walk, or telecommute for both work and personal trips. These points can be used for restaurant coupons, shopping discounts, and attraction tickets. NuRide partners with public agencies, employers, and businesses to sponsor the incentives. Similarly, RideSpring works with employer commute programmes and participating employees can enter monthly drawings for prizes from over 100 retailers (RideSpring, 2010).

Social networking platforms

The rise of social networking platforms, such as Facebook, has enabled ridesharing companies to use this interface to match potential rides between friends or acquaintances more easily. These companies hope that social networking will build trust among participants, addressing safety considerations. One example is Zimride, which has partnered with 86 US and Canadian colleges, universities, and companies that each has their own "network" of members (Zimride, 2011). In addition to each network's website, Zimride also uses the Facebook platform to attract public users. Another service is PickupPal (2011), with over 156 000 members in 120 countries. It allows members to create their own groups based on common area, company, school, and shared interests. However, social networking may limit itself by relying on more isolated groups and excluding less tech-savvy users. At present, there are four major North American ridesharing programmes focused on social networking: GoLoco™, Gtrot, PickupPal, and Zimride.

Real-time ridesharing services

In North America, two companies are beginning to offer real-time ridesharing services: Avego™ and Carticipate. Real-time ridesharing uses Internet-enabled "smartphones" and automated ridematching software to organize rides in real time. This enables participants to be organized either minutes before the trip takes place or while the trip is occurring, with passengers picked up and dropped off along the way. These programmes attempt to address the inconvenience of traditional carpooling and vanpooling. As in most ridesharing services, a high subscriber base is required.

These key developments and their target journey purposes are summarized in Table 3.

Ridematching programmes statistics

As of July 2011, the authors estimated that there were 638 ridematching services in North America, based on an extensive Internet search. This tally includes both online (most have an Internet-based component) and offline carpooling and vanpooling programmes. Those located in sparsely populated rural areas, which appeared to have very low use, were excluded. Institutions that have

Table 3. Key developments in phase five

Development	Primary target journey	Examples
Partnerships between ridematching software companies and regions and large employers	Regular commutes	Goose Networks, Trapeze RidePro, RideShark
Financial incentives for "green trips" through sponsors	Regular trips	NuRide, RideSpring
Social networking platforms that target youth	One-time or occasional trips	GoLoco™, Gtrot, PickupPal, Zimride
Real-time ridesharing services	One-time or occasional trips	Avego™, Carticipate

their own ridematching website but employ a common platform were each counted separately. Of the total, 401 are located in the USA, and 261 are in Canada (24 programmes span both countries). Carpooling attracts the largest focus, with 612 programmes offering ridematching, and 153 providing vanpool ridematching; 127 offer both.

Ridesharing's future

The lessons learned from previous and existing ridesharing services and policies have led to a limited, but growing, body of knowledge. This along with ongoing technology and policy developments will contribute to ridesharing's evolution over the next decade. In this section, the authors discuss three key areas that will likely influence future developments: technology interoperability and integration, enhanced casual carpooling, and public policy.

Not surprisingly, technology will play a critical role in ridesharing's future. Perhaps its greatest contribution will be to help overcome the critical mass barrier, which has limited the potential of this mode in the past. Interoperability among numerous ridesharing databases could achieve a notable step in this direction. Open source data sharing among ridematching companies could enable members to find matches across all databases. This would require a standard protocol that shares data, while still maintaining competition among firms. OpenTrip is one proposed protocol format, which is still in development (Gorringe, 2009). Another idea is a "ridematch aggregator"—a website or other interface that searches all ridesharing databases. The online travel agency industry already employs such aggregator websites.

Another area that could foster growth is multimodal integration—the seamless connection of ridesharing with other transportation modes, such as public transit and car-sharing. Indeed, Zimride and Zipcar (the largest North American car-sharing operator) launched an integrated partnership in 2009 (Reidy, 2009). The Zipcar–Zimride application enables university members to share rides by posting their trip date, time, and destination to the Zimride campus community. If a ride is not matched, Zimride members can also share a local Zipcar. In the future, travellers could go online to view travel times and costs by mode and choose which is best for them (A. Amey, personal communication, 26 July 2010). Multimodal integration could even facilitate transfers between modes, making alternative transportation more convenient. A significant challenge to future integration and interoperability, however, is the establishment of institutional arrangements that could facilitate collaboration among public agencies and private companies to support this.

While many in the ridesharing industry focus on technology to increase modal share, others emphasize "meeting places", such as casual carpooling sites because they do not require prearrangement (M. Oliphant, personal communication, 15 July 2010; P. Minett, personal communication, 22 July 2010). In the future, "enhanced" casual carpooling could incorporate transponder technology into casual carpooling systems to guarantee membership and participant payment (Kelley, 2007). One proposed system is formalized flexible carpooling. Marin County, California, implemented a rudimentary programme from 1979 to 1980, which employed major intersections near bus stops as designated meeting places (Dorosin, 1981). Future formalized flexible carpooling programmes could build upon this idea. In July 2010, the Washington State Department of Transportation announced its Flexible Carpool Pilot Project, which plans to incorporate Avego^{TM}'s smartphone ridematching technology with flexible carpooling along high-volume commuter routes in the Seattle metro area (Avego, 2010).

Finally, supportive policies in the USA and Canada are essential to facilitating ridesharing growth over the next decade. A range of TDM policy strategies could integrate and promote ridesharing, such as free or reduced-price access to high-occupancy toll lanes, parking cash-out (employees can opt out of a parking space and receive compensation from their employer who leases/owns the space), and pretax commuter incentives (commuter is not taxed on ridesharing expenses). Ultimately, effective policies must demonstrate to employers and travellers that ridesharing will positively impact their lives through tangible incentives.

Conclusion

Ridesharing has evolved through many stages since its beginnings 69 years ago. The authors categorize North American ridesharing into five key phases: (1) World War II car-sharing clubs; (2) major responses to 1970s energy crises; (3) early organized ridesharing schemes; (4) reliable ridesharing systems; and (5) technology-enabled ridematching. In the first phase, government and employer ridesharing promotion greatly spurred travellers to conserve resources for the war effort. The re-emergence of ridesharing during the late 1960s and 1970s was characterized by efforts to conserve fuel through policy measures to increase vehicle occupancy. After observing the success of employer-sponsored carpooling and vanpooling programmes, policies promoted carpool demonstration projects, HOV lanes, and park-and-ride facilities. The 1980s marked a shift away from national policy, with early organized ridesharing schemes mitigating traffic congestion and air quality issues on a more regional basis through local TDM measures and telephone-based ridematching systems. The fourth phase reverted to more reliable systems, incorporating the Internet to attract more users. Online ridematching and traveller information services began during this phase and targeted commuters with the most reliable trip schedules.

Today, there are an estimated 638 ridematching services in the USA and Canada. Phase five is characterized by the incorporation of the Internet, mobile phones, and social networking into ridesharing services. Moreover, the development of ridesharing platforms spurred expansion to regions and employers throughout North America. Key developments include regional and employer partnerships, financial incentives, and social networking to younger populations to achieve critical mass. Several companies have begun real-time ridesharing through smartphones and automated ridematching technology, but they still require a higher subscriber base.

Over the next decade, North American ridesharing is likely to include greater interoperability among services, technology integration, and policy support. These developments also apply to other parts of the world, such as Europe. Particularly in the UK, a 2001 survey of employees found a significant potential for carpooling to reduce commuter traffic, with over half the respondents stating help for finding carpool partners as very important (Kingham *et al.*, 2001). At the same time, a UK Department of Transport study found that only 1% of households were part of a formal ridematching programme (Robinson *et al.*, 2007). Thus, as in North America, more ridematching assistance could result from technology integration and policy support. For instance, a European study proposed an integrated system of ICTs to organize a carpooling service (Calvo *et al.*, 2004). Moreover, national agencies dedicated to ridesharing research and funding could substantially spur growth through a concerted effort to enact such policy measures (C. Burbank, personal communication, 27 July 2010). Additionally, research into the behavioural economics of modal choice is needed to determine which psychological and emotional factors are involved in choosing between driving alone and ridesharing (R. Steele, personal communication, 23 July 2010). A key lesson learned from past programmes is the importance of marketing and public education to raise awareness about ridesharing and its potential to reduce climate change and traffic congestion. Nevertheless, ridesharing's full potential is unclear. Among the industry, there is much debate over whether to emphasize technology and social networking or financial incentives and enhanced casual carpooling (P. Minett, personal communication, 22 July 2010; R. Steele, personal communication, 23 July 2010; S. O'Sullivan, personal communication, 21 July 2010; J. Zimmer, personal communication, 21 July 2010). Moving forward, more ridesharing research is needed to better understand the role of behavioural economics, interoperability, multimodal integration, and public policy, as well ridesharing's impacts on infrastructure, congestion, and energy/emissions.

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