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Research Article

MOBILITY-ON-DEMAND SERVICE IN MASS TRANSIT: HYPERCOMMUTE OPTIONS

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ABSTRACT

Digitization, increasing automation and new business models like shared mobility have revolutionized transportation and mobility. Ridesharing companies like Uber and Lyft provide technological platforms and support to connect drivers and riders on the basis of demand-response services. Although the most improvements in on-demand applications have been experimented in private transit services, there is no any implementation in public transportation to connect public transit services and passengers each other. On-demand is still vague. However, providing on-demand services in public transportation is complicated because of the big capacity problem in mass transit, its application in public transit services can enable flexible mobility for riders and provide personalized mobility experience. This paper presents the concept of mobility-on-demand service and its application in public transit services with an technological innovation of FM/LM pilot project represented by HyperCommute. The paper starts with introduction, then the business model of mobility-on-demand service is described and the most used algorithms are explained, then an illustrative example of HyperCommute mobility-on-demand service is given. Also, the applicability of mobility-on-demand service in Istanbul is discussed. The paper ends up with conclusion and future directions.
Keywords: Mobility-on-demand, mobility, HyperCommute, dynamic ridesharing, public transportation, digitization, route analytics.

1. INTRODUCTION

An increased population growth on travel can cause lots of problems - like, travel time uncertainty, traffic congestion, accidents, inadequate parking spaces and air pollution (greenhouse gas emissions and particulate matter) - for economy, society and environment [2][4][19]. Both industry and academia have spotted these problems as a new research area. The major problem is that the most cities have not adequate urban infrastructures as well as numerous inefficiencies in public transportation system to sustain the growth in the number of vehicles. In addition, most existing resources are underutilized or riders may not get satisfactory transit services. Therefore, public transport authorities are looking for new solutions in order to fulfill commuting requirements. Instead of adding new bus lines or building train tracks for public transit services, cities turn to the sharing economy to build out their fully integrated transport networks. This situation presents new challenges and opportunities with the advancements in Internet and mobile

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technologies w hich should be addressed in parallel with the interest of long-term urban sustainability and public concern.

The ubiquity of Internet-enabled smartphones provides on-demand app-based ride services, named ridesharing or ridesourcing are quickly expanding mobility options in urban cities as an important component of sustainable urban transportation, as it increases vehicle utilization while reducing road utilization [6][9][11][17][25]. Recently, many new ridesharing companies like Lyft, Sidecar, Avego, UberX and Flinc have emerged in both the U.S. and Europe that offer smartphone applications in order to match up drivers and riders [11][22]. The aim of the ridesharing system is that drivers offer free seats in their vehicles to the passengers for the same or similar travel direction either for permanent repeating needs for a ride (e.g. commuting) or in sharing a ride for long-term planned journeys (e.g. going on vacation) [23]. However traditional ridesharing services are more suitable for long-distance rides, especially for intercity purposes, there is not much flexibilities for short-distance rides or last miles within the cities [22][24]. Furthermore, mobility-on-demand applications have been experimented mostly in private services and partly in freight transportation. As yet, there is no implementation in the public transportation for first-mile/last-mile (FM/LM) to connect operators (public transit services) and riders (passengers) each other on-demand matter. Transit systems in urban network include mainly bus, shuttle and rail services. They serve to carry typically multiple passengers, and so that traveled distance for each vehicle can be gradually reduced and the traffic congestion is eased in the cities. The services offered in the public transport system operate on fixed routes and schedules at present, this limits transit coverage, both geographically and temporally and there is not yet a dynamic service application for FM/LM which can respond to the changing mobility needs of the passengers and offer personalized mobility experiences. On-demand service solution is still vague. However, providing on-demand services in public transportation is complicated because of the big capacity problem, when it comes to shuttles and mass transit. The aim of this paper is to present a dynamic mobility-on-demand service for public transportation system to solve the commuting problem on the basis of integrated dynamic transit operations and dynamic ridesharing. Solving commuting problem requires a hyper-connected system, in which on-demand requirements of commuters are dynamically analyzed and aligned with the capacity of components. This system is called as Mobility-on-Demand (MoD) service in order to indicate a complex and integrated dynamic commuter system. A software-based, online enterprise mobility solution of MoD are often called as Mobility-as-a-Service (MaaS) system. The aim of MoD is to reduce the private car ownership and promote to use mass transit by implementing dynamic on-demand mobility services. In this paper, a MoD service platform for transit services is presented, then an illustrative example of a MoD service platform, namely HyperCommute with its implementation in a shuttle network is demonstrated. In addition, applicability of MoD service in Istanbul is discussed. Finally, the paper ends with conclusion and future directions.

2. THE BUSINESS MODEL OF MOBILITY-ON-DEMAND SERVICE

The public transit system cannot be operated the same way what was done 50 years ago and it is expected to be relevant. It is required changing the way of thinking about mass transit. Technology and new types of transit are used to both entice and provide the type of experience the customers want. The MoD service brings a transportation paradigm shift in the way in which public commute can be perceived totally different than how it is now. That means, MoD enables a dynamic mobility service platform for mass transit on-demand which is capable of matching random transport ride offers at any time and accommodating quickly any commuter request for near-term (e.g. same day) as well as long-term (e.g. future days or weeks) rides [8][21]. It supports multi-modal trip matching for both public and/or private transit services and is thus the ideal solution to address the FM/LM problems. MoD as a demand-responsive dynamic mobility service combines the integrated dynamic transit operations (i.e. dynamic scheduling, dispatching, routing) of public transit services and dynamic ridesharing (also called real-time or instant ridesharing or carpooling) of private transit services. MoD is multi-modal and multi-agency. In the *Dynamic Transit Operation*, traveler accesses real-time information on travel options, costs and arrival times whereas agency extends demand/response services to support dynamic routing and scheduling and add/remove vehicles from service based on traffic conditions, vehicle capacity, ridership and origin-destination. *Dynamic Ridesharing* leverages the positioning, messaging, and computing capabilities of smartphones to allow drivers and riders exchange information in real time. The system is operated by grouping ride requests on similar routes. A basic definition of MoD service is "*a technology-enabled demand-responsive dynamic mobility service that facilitates matching the public and private transport capacity and commuter demand and it enables riders to hail or schedule rides close to their departure time, with sufficient convenience and flexibility to be used on a daily basis*".

The MoD service helps (i) to reduce congestion by eliminating cars from the road and maximizing high-occupancy vehicle lane (HOV) use, (ii) lower costs of commutes for users by cost sharing or eliminating the need for a car, (iii) to decrease auto emissions by removing cars from the road and allowing more efficient speeds, (iv) to reduce the public transport waiting time and (v) to reorganize the routes and schedules via using data analytics.

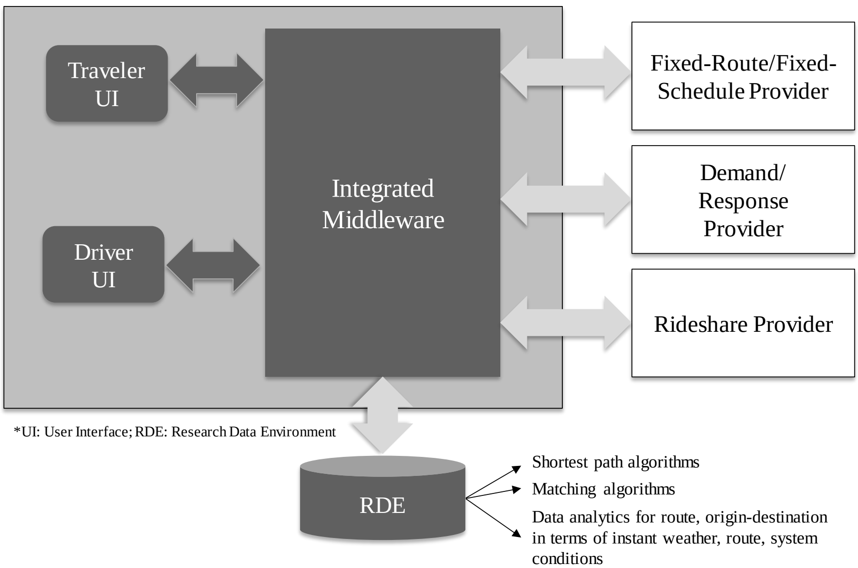

Figure 1. Conceptualization of Mobility-on-Demand services [6]

The advanced technologies and automated systems (e.g. smartphone technologies, mobile application development platforms and online payment systems) can accelerate information exchange both internally and between the public/private transit services and passengers and analysis for ridesharing and ride matching with minimal input. The main idea of MoD service is to offer daily commuters through using smartphone applications a personalized mobility experience for FM/LM connections by providing a multi-modal trip-sharing interface that will allow the integration of fixed-route transit and paratransit services, where commuters can use the public transit services as well as private transit services to travel from origin to destination (O-D). The focus is on transporting passenger to/from a main bus stop to their home address; however, rides from any address to any address would be possible. The business model of MoD is based on a new and unique technology that integrates fixed route, demand response as well as rideshare services together as seen in Figure 1 and allows riders and transit operators to match a beginning and end location to at least two or more carriers. The MoD service has an integrated middleware with the user interfaces for travelers and drivers which enables access to transit operators for fixed route, demand response and rideshare and also middleware connects data to calculate and match the demand and offer. A key component of this concept is to ensure that scheduled connections are made through both technological and operational solutions.

This service requires a dynamic environment as commuter request can come randomly and services can check whether the request is acceptable or not after comparing with the capacity. Public transit services can be used with dynamic routing and scheduling function for FM/LM and private services can be used with dynamic ridesharing function for last-last-mile or vice versa, moreover this combination can be done also for first-mile, but main-mile should be completed with a static routing function of public or private services. As transport means, public transport vehicles (bus, shuttle and rail) and private vehicles (private car, taxi, collective taxi) are provided. This means that MoD service brings all public and private services as well as commuters together to a platform in order to provide convenience for the system users and improve the system wide performance such as reduction in vehicle traveled distance, lower costs of commuters and services, reduce congestion and decrease emissions by eliminating/removing cars from the road and allowing more efficient speed [10].

Dynamic transport operations enable system users (travelers, riders, commuters) to get accessed real-time information on travel options, costs and arrival times, whereas transport service providers (public/private agencies) extend demand / response services to support dynamic routing and scheduling and add/remove vehicles from service based on traffic conditions, vehicle capacity, ridership, origin-destination, etc. [4]. Dynamic ridesharing leverages the positioning, messaging, and computing capabilities of smartphones to allow drivers and riders exchange information in real time. The dynamic ridesharing process is more flexible hence the system is capable of matching random rides at any time and responding quickly to any request even if the request of ride offer is created during the same day or even en-route. Here the system provides all possibilities to match transit capacity and commuter demand by one-to-one, one-to-many, many-to-one, and many-to-many configurations.

2.1. System architecture

The design of MoD system architecture seen in Figure 2 comprises three-tier layers: data layer, logic layer and presentation layer. (i) *Data layer* is responsible for storing configuration information where transit vehicle status and position, routes and schedules, traveler info and trip info are stored. (ii) *Logic layer* is the core of the system and provides various services such as trip routing engine, route and schedule manager account management and data logging. It is accessed through web service Application Programming Interface (API) that are provided for writing client code that communicates with the system. (iii) *Presentation layer* communicates with the logic layer through a web service API, performs data layout and formatting actions. Traveler portal, web service API and administration portal are presented in this layer and also it provides user interfaces for travelers and transit operators.

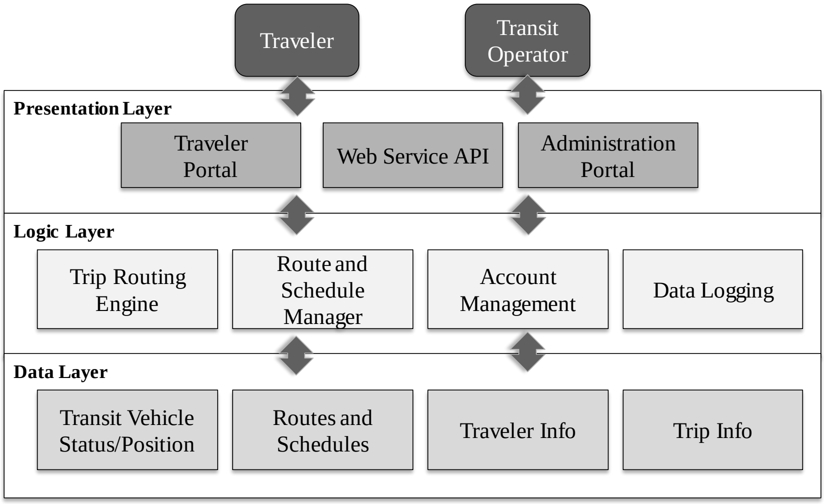

Figure 2. Architecture design of Mobility-on-Demand services [6]

There are different ridesharing and ride matching possibilities such as Internet/Global Positioning System (GPS)-smartphone computerized ride matching, Internet-based computerized ride matching, and telephone-based computerized ride matching [6]. The use of smartphones with integrated GPS devices have been very common for navigation among the most of the dynamic ridesharing services. This system enables real-time monitoring and it makes possible to assume that the users are always traceable and have permanent connectivity and reachability [23]. Real time traffic data can be sourced as applications from smartphones such as, Google Maps, TomTom Go Mobile, Here WeGo or INRIX XD Traffic, in the browser on the desktop computer or notebook which can be used from a variety of sources to determine the traffic situation.

The MoD service has mainly four features with the aspects of dynamic transit operations and dynamic ridesharing:

1) multi-hop route feature: capable to provide multi-hop routes to riders,
2) optimal routing feature: capable of optimally routing drivers,
3) real-time matching feature: capable of making driver-rider matches in real-time, and
4) multi-driver multi-rider matching feature: equipped with a ride-matching algorithm produces the optimal (or near-optimal) match for multiple drivers and riders simultaneously [18].

MoD is an innovative transportation concept, there are only limited real-world applications mainly in U.S. which will be explained in the next section. Because of the huge capacity issues, MoD service would have some difficulties in a complex transport system such as accuracy in routing vehicles and supply projection among others and also this service could not work efficiently with poor Internet connectivity. Beside these difficulties, MoD is easy to add as on-demand service and commuters can have a personalized mobility experience by using easy-to-use smartphone applications, which is more or less Uber like experience with the combination of public and private transport services. This service can provide passengers more comfort, shorter travel times and also low fares.

3. ALGORITHMS IN MOBILITY-ON-DEMAND SERVICES

MoD services can provide not only a personalized mobility experience but also ensure efficiency and sustainability by large scale ride pooling. MoD service requires mathematical models and algorithms that can match large groups of riders to a fleet of shared vehicles in real time. Here, it is important to measure rider commuting behavior between any departure / arrival point (picked up/dropped off) in an urban area, for that several algorithm techniques can be used such as route analytics, origin-destination analytics, shortest-path and demand matching algorithms. The algorithms allow trip sharing by grouping similar trip requests in space and time, thus support dynamic routing of FM/LM vehicles. The real time aspect of the algorithms incorporates last minute changes like trip cancellations and ride requests. These algorithms can be explained as follows:

3.1. Shortest path algorithm

There are numerous route calculation algorithms in the literature [20]. The most used algorithms are Dijkstra's Algorithm, Basic A* (A star) Algorithm, ALT, REAL, SHARC, Core-ALT and CHASE [5][14]. The aim of using these algorithms is to find a shortest path (having the minimum length) between any two nodes (e.g. O-D) of a connected and weighted urban network. Table 1 gives the short explanations of the most used shortest path algorithms.

Table 1. Shortest path algorithms

Algorithm	**Short explanation**
Dijkstra's algorithm	It is the classical shortest path finder algorithm for bidirectional search. It calculates the shortest paths from a given source node to each of the other reachable nodes in the graph.
A* (A star) search	It is a technique greatly used in artificial intelligence. It guides the search of Dijkstra's algorithm towards the target node by using lower bounds on the distance to the target.
ALT algorithm	It is based on A* search. Using the triangle contrast, strong bounds on shortest path distances can be gained by precomputing distances to a set of landmark nodes that are well spread over the far ends of the network.
REAL	It is a combination of REach and ALt. It stores landmark distances only with the nodes that have high reach values, which in result can significantly reduce memory consumption.
SHARC	It extends and combines ideas from highway hierarchies (namely, the contraction phase, which produces SHortcuts) with the multi-level ARC flags. The result is a fast-unidirectional query algorithm, which is advantageous in scenarios where bidirectional search is prohibitive.
Core-ALT	It iteratively holds nodes that do not require too many shortcuts. Then, on the remaining Core, a bidirectional ALT algorithm is applied.
CHASE algorithm	It is the combination of Contraction Hierarchies and Arc-flagS with highway node routing.

3.2. Matching algorithm

In MoD, in order to enable dynamic operations and ridesharing, the shortest path problem is improved by the ride-matching problem with the dynamic setting requirements. Several studies have been published in order to address the matching problem in dynamic ridesharing, although all developed techniques refer the private ride services, there is no any application in public services. The matchings between riders and drivers are completed via a matching algorithm implemented at the ridesharing platform [27]. Agatz et al. (2011) [1] developed an optimization based approach with a rolling horizon strategy. A simulation study is assessed to show that matching algorithms are important to make dynamic ridesharing useable. Masoud and Jayakrishnan (2015) [18] developed a fully-flexible peer-to-peer (P2P) ridesharing system, where they used flexible routes in order to provide optimal (or high-quality near optimal) solutions in a short period of time. Geisberger et al. (2010) [12] provided an algorithm that finds suitable matches with the smallest detour distances. Ghoseiri et al. (2011) [13] offered a large model with using different preferences, such as age, gender, smoking, pet restriction and maximum occupancy, however this model can solve only small instances. Jung et al. (2013) [15] provided solution techniques for optimization problems in dynamic ridesharing by using simulated annealing heuristics for shared-taxi. Tao and Chen (2008) [26] developed an algorithm for the related problem of dynamic ride-matching for taxi pooling services by using greedy heuristics. The efficiency and effectiveness of the matching algorithm depends on the settings of the algorithmic parameters, especially on the vehicle capacity [3][16]. For vehicles with low capacity, such as taxis, the optimal path can be computed via an exhaustive search, whereas for vehicles with larger capacity, such as buses, shuttles, heuristic methods such as Kernighan–Lin algorithm, Tabu search, or simulated annealing may be used.

Figure 3. GTFS code-based visualization

3.3. Data Analytics

Data analytics for route and origin-destination can be used to identify MoD potential among drivers by grouping vehicles by trajectory similarity in real-time and also to measure passenger commuting behaviors [7]. Moreover, these analytics support and accelerate decisions and enable better fulfillment of the commuter's needs while providing lower capacity availability for vehicles at the same time through improved predictability of demand as well as of commuter related incidents (i.e. understanding in which O-D-pair the routes are frequently used by commuters). The Figure 3 depicts a General Transit Feed Specification (GTFS) code-based visualization for public services which informs passengers which bus stops are available on a network and in what direction buses are on the way. The GTFS-real time-based visualization have been already used for some ridesharing applications such as, taxi call services (e.g. Bitaksi) and private car services (e.g. Careem, Olev, Uber, Yolo). Machine learning techniques are used for the road network training. Usually the travel times are timed at the stops and not for all the legs (segments) on the path between two stops. In MoD service, travel time for every leg is approximated after several observations and then a model to train the road network is accommodated the human learning for accurate transit times. For example, supposing a bus is timed between two consecutive stops (A and B) at t1 and t2 and if there are 3 legs (L1, L2, L3) between A and B. The transit from the existing model: A-B = t, L1 = m1, L2 = m2, L3 = m3. The humanly timed transit time between A and B is (t2-t1). The update leg durations are corrected as follows: L1 = m1(t2-t1) / t, L2 = m2 (t2-t1)/t, L3 = m3(t2-t1)/t. This leg is used transit information to update the road network with transit times for all the routes that have these legs in their paths. After initialization, machine learning models are used to infer the transit times from alternate vehicle modes.

4. ILLUSTRATIVE EXAMPLE FOR MOBILITY-ON-DEMAND PLATFORM: HYPERCOMMUTE

A simulation example is selected in an urban area to demonstrate a MoD service with a real-world application. HyperCommute is a MoD service and it operates demand responsive travel based on dynamic passenger information. A shuttle service of TCAT (Tompkins Consolidated Area Transit) is used as a test bed for stations and routes in Ithaca, NY. The simulation demonstrates an innovative way to dynamically determine shuttle routes in real-time to meet on-demand request of riders. Riders are able to access the system in real-time through a free mobile app, website or by calling a dispatcher. The customer interface also allows riders to receive information about the location of the FM/LM service pickup, the status of the FM/LM vehicle and the location and status of the fixed-route bus. The various performance parameters have been measured to mark the effectiveness of dynamic routing in shuttle transportation. The application also provides some insights into riding parameters and serviceability through heat maps, O-D analytics, road analytics etc. HyperCommute uses an algorithm. The key aspects of the algorithm as follows:

- The matching engine provides for an optimized way of calculating the cost of matching demand to a dynamically-built route and is configurable enough to choose various cost metrics like distance, time or a weighted function of the two.
- High-speed dynamic routing engine ingests real time updates and performs feasibility checks at blazing speed to optimize riding experience.
- Machine learned corrections improve the accuracy of the calculations and helps meet Service Level Agreements reliably.
- The algorithm is built on complete road network with turn-by-turn details and is frequently updated for transit times, traffic and weather updates.

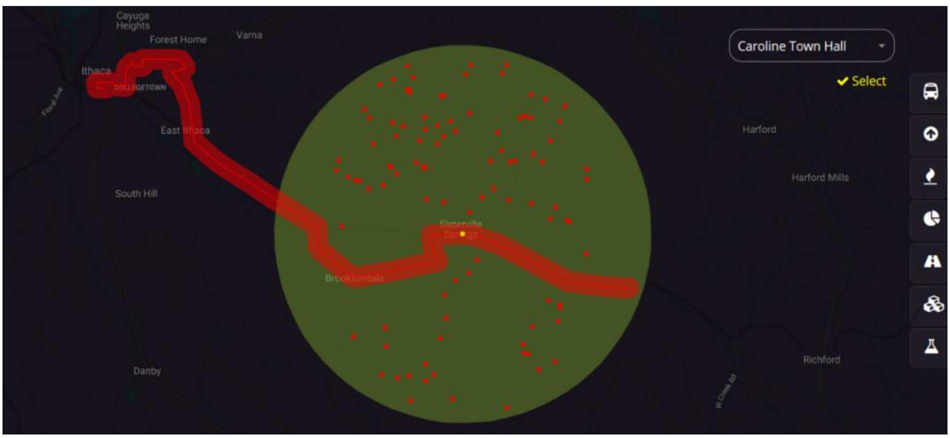

Figure 4. Selected hub with stations and routes

As transport means, shuttle busses with 7-8 seats are used. To demonstrate the HyperCommute, first of all, a hub area is selected, where all available stations and routes are determined, and in the meantime, the passengers commuting requests are randomly collected, seen in Figure 4. Here red line shows the fix routing for long-distance, whereas red doted green area shows the dynamic routing for the last miles. Route lines in the green area will be determined according to commuter demands real-time, critical mass is important in order to create a line dynamically, that means the number of the boarding as well as deboarding commuters will give instant decision to drive route dynamically. Though most commuters prefer to prearrange commutes at least the night before, HyperCommute promotes shuttle pooling regardless of the time available for planning. Riders may stand at bus stops or use one of many private services through an application on their smartphone that automatically pairs them with a driver. If the rider is near a bus stop, the rider benefits from having another travel option and may use transit service as a safety net in case a single driver does not arrive. The driver benefits with lower travel time by qualifying as a vehicle pool in a managed lane and a potential monetary benefit from receiving payment for picking the rider up. The simulation minutes and waiting minutes are set, then the simulation is run, so that commuter demands according to service lines are matched, Figure 5 depicts the matched demand and shuttle lines. For instance, 6 out of 29 commuter demands couldn't be matched with 5 shuttle lines during the period of time, whereas 23 is matched, so that the service level is about %75 for this run. If the routes are clicked then it will give the rescheduled five shuttle lines according to dynamic routes, seen in Figure 6. According to time distance, it gives at what time, which shuttle arrives to which station and how many commuters board/deboard at the station, so that transit company can analyze commuter demand and adjust the vehicle capacity.

HyperCommute is essential in that it underlies the reliability of transfers from FM/LM vehicles to fixed-route transit (and vice versa). The algorithm ingests real-time transit vehicle position and maps it to the route building process to compute the optimal transfer points. Alternatively, an agency can establish accepted transfer point from the outset and the software will optimize transfers at these locations. The system infrastructure is built to facilitate the transfer by sharing information with the drivers and dispatchers - allowing an agency to schedule transfers as tight as can be reliably managed. This removes one of the barriers that riders often cite when asked to transfer between two vehicles to complete a trip: anxiety that the connection will be missed if scheduled too tight or dissatisfaction with long wait times if the scheduled transfer is too long. HyperCommute is unique in the market in its ability to support optimized, anxiety-free multimodal transfers. HyperCommute is also focused on creating a great customer experience. User interfaces provide information about the availability of services to reach transfer points in a real-time fashion. A rider then can request a ride on a suitable transportation mode through these interfaces. The riders get notified about the pick-up time and location and will be able to track the vehicle. Vehicle Estimated Time of Arrivals (ETAs) are updated in real-time and riders are notified about any changes or delays. The user interfaces are available for Web, iOS or Android and they offers downloadable application through traveller-owned device. The interface allows for trip planning, viewing current trip details, trip history and notifications (not available via Web).

Figure 5. Matching the commuter demands and shuttle routes

Figure 6. Rescheduled shuttle lines according to dynamic routes

This illustrative example demonstrates only the integrated dynamic transit operations through dynamic routings in the last-mile, whereas dynamic ridesharing is missing, as this function is currently under developed. There are several real-world examples of MoD services. As some cities in U.S. are helping commuters integrate ridesharing services into trip planning, with smartphone applications that allow riders to plug in a destination and get various public or private travel options and the best combinations. Recently, a public transit service and a ridesharing service, namely Dallas Area Rapid Transit and Lyft have partnered to offer a first-last-mile program for mass transit users. Riders can use the smartphone application to connect with a driver, then connect to a bus or light train. However, the dynamic part of the system relies on only ridesharing part, whereas the public transport part is associated with the fixed or static routing. In NY City, passengers use the metro lines and ride sharing service of Uber interchangeably, which is operated by Uber’s apps. In Nashville, TN, TransLoc Rider app is testing an on-demand van service that takes riders crosstown, a trip that has less fixed-line public transit service than other routes. In Seattle, King County Metro, TripPool app, providing on-demand rideshare options to connect riders to transit in select areas. Metro-provided commuter vans make one round-trip each work day to a park & ride or transit center. In Austin, TX, CapMetro Trip Planner app is used to order a shared ride with the tap of a button from the city’s transit agency.

5. MOBILITY-ON-DEMAND APPLICABILITY IN ISTANBUL

Istanbul has a very large as well as complex public transport network with the more than 6 million of daily commuters. Keeping this network up and running is one of the top priorities of local authorities. Some actual statistics (take from https://moovitapp.com/insights/tr/Moovit_Toplu_Taşıma_Kullanım_İstatistikleri-1563) can be given that the average daily travel time is about 1.5 hours and 12 km, approximate waiting time at the stop is about 19 minutes and only 30 percent of mass transit users is long-distance commuter. The inherent complexity of transport network and unexpected problems, such as traffic congestion, accidents, system shutdowns, weather conditions among others, make very hard to sustain an efficient and effective system for daily commuters. Moreover, current public transport applications cannot provide the O-D information in terms of alternative transport routes, vehicle mode variety, time delay and so on. Therefore, Istanbul's transport system strongly requires applicable and complementary solutions. From this aspect, MoD service would have huge potential to apply in such mega cities like in Istanbul. The entire city is surrounded by various public transportation routes (e.g. rail, bus, metro, ferry, funicular) with various vehicle modes (bus, maritime, railway operators, taxi, minibus and shuttle operators) seen in Figure 7. Moreover, there are a huge amount of private transit services and all these can be connected very well by MoD service. Currently some ridesharing applications for private transit services such as Uber, Bitaksi can be seen in Istanbul as well. The majority of the mass transit users in Istanbul use the transportation system for short-distance purposes, to make the commuter travel more efficient, the FM/LM connections can be operated with dynamic short bus lines and also with dynamic ridesharing services, whereas the main-mile can be run with fixed routing services like metro, long bus lines. However, application of MoD service in Istanbul would potentially problems in terms of unexpected traffic conditions, accuracy of supply information, poor Internet connections and beside these, adaptability of older generation to this service would be difficult, as this service would be more acceptable from smartphone users.

Figure 7. Mass transit system of Istanbul

6. CONCLUSIONS AND FUTURE DIRECTIONS

The main objective of this paper was to demonstrate a MoD service platform for public transportation system. Mobility requirements have been growing immensely because of the traffic congestion and cost issues, therefore new user-centric services are transforming urban mobility by providing timely and convenient transportation to anybody, anywhere, and anytime [3]. Daily commuters generally tend to use public transportation system, which is very convenient to use especially during rush hours. This system normally runs along predefined routes (fixed routing), there is not much flexibilities for short-distance rides, like FM/LM, moreover, the current system cannot accommodate commuter real-time demand, this could result in unutilized vehicle capacities and substantial economic inefficiencies. Combining dynamic transit operations such as dynamic routing and scheduling as well as dynamic ridesharing for last miles in public system can be as an option to fulfill the commuter requests for mass transit. MoD service is much practicable solution and it provides more potentials in the large cities by enabling lesser waiting times, guaranteed travel times and maximum utilization. From this point of view, MoD service can be offered for short-distance in big cities like in Istanbul. Advanced technologies and automated systems can boost the interactions of system users and components and stimulates hyper-connectivity. As future directions, MoD service can offer the combined commute experience for riders with the combination of dynamic routing in public services and dynamic ridesharing in private transit services, which can enable the most effective and efficient transit service within any O-D-pairs. However, there are still some questions in MoD service to answer like “how are the dynamic routes created? How are they scalable to bigger order size? How is ensured on-demand experience for customers? What should be the optimal asset size? How is the supply repositioned? What kind of local decision making is required in assigning orders to buses? How is it aligned to global optimum? Why multi-threaded application will be suitable for on-demand service? What kind of automations are required?”. The advanced models will respond these questions so that MoD service will convey better results.

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