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Virtual Taxi Stand Management System

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***Abstract*—Taxi is an important mode of transportation within modern cities. The key value propositions they provide are the efficiency and flexibility of the service. Quality assurance of the taxi service within a growing city has been a common challenge faced by many modern cities. Both taxi drivers and commuters regularly encounter frustrations caused by traffic and weather conditions. In this paper we will discuss on our proposal of how Virtual Taxi Stands are able to address the common frustrations faced by commuters and taxi drivers by augmenting information from various external sources.**

***Index Terms*—Transportation, Mobile Device, Planning, Dynamic Systems**

I. Introduction

TAXI has been an important mode of transportation for people to travel around over the years. People frequently engage in taxi trips because of the efficiency and the flexibility of the service. Such convenience has made commuters willing to pay higher fees to take a taxi than other public transportation.

As the population of a city grows ensuring a high quality taxi services to meet the demands of commuters is increasingly difficult in many modern cities. In the taxi drivers perspective, the taxi utilization rates are important in helping them to increase their earnings. As for the commuters, they desire both minimal waiting time and lower charges to reach their destinations in time. For the government authorities and taxi operators their key objective is ensuring a high quality of service and maintaining a healthy transportation system.

Two widely used solutions are adopted in many cities for commuters to engage a taxi. The first is a booking service at which the commuter would pay a higher premium to secure a taxi at a specific time and location. Beside the traditional booking service through call centres, the advancement of technology has allowed crowd sourced model for hailing and booking taxis to be developed via mobile application platforms. Such solution provides a personalized service for the commuter where a particular taxi would be allocated for each booking.

The second is the designation of taxi stands at designated locations (e.g. malls, transportation hubs) to direct both the commuters and taxis to a common location. The location of a taxi stand is normally placed at buildings with a high volume of human traffic. In particular transportation hubs such as airports, ferry terminals, bus interchanges, and train stations.

Recent advancements in mobile technology have enabled commuters to better indicate their needs while taxi drivers have better understanding of the demand. Motivated by the above facts and trends we designed a solution that creates a virtual taxi stand where both the taxis and commuters within the vicinity would be directed to it. Our solution while addressing the needs of commuters and taxi drivers will also address other transportation related issues such as improving the traffic conditions of the road, reduction of bottlenecks, and better distribution of services and demands of taxis.

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II. Related Works

There have been several mobile applications for hailing or booking a taxi. These applications [1], [2], [3] allow customization of commuters hailing or booking requests by defining the type of taxi (e.g. 6 seater, handicapped) they require. Moreover, the taxi drivers can also detect the demands and location of the passengers at different locations through the mobile application. This is done through push notifications or indications of the demands on the map through the mobile application.

However, there are three main limitations in these application solutions. Firstly, it does not necessarily meet the road regulations set by the local authorities or follow the restriction on areas to hail or board a taxi. Secondly, it also lack in the unification of the pick-up location which encourages bypassing of queues when hailing a taxi (for e-hailing applications). Lastly there would also be congestions caused by taxis having to pick up passengers based on their location. Such problems are social in nature which can easily escalate into more serious issues if they are not well attended to.

The existing solutions also inadvertently create disjointed sets of information on the transportation supply and demand requirements. Data gathered within each solution would not be readily shared between each other. This places the need for both commuters and taxi drivers to access multiple systems in order to obtain the bigger picture. In this way information is not only repeated but might also be outdated or incomplete.

III. Proposed Solution

We propose a solution that enables commuters to create/join a virtual taxi stand based on their location, weather information, and traffic condition. Our solution consists of three major components, a mobile application (commuter), the central control (government authority/operator), and demand indicator (taxi).

Our solution starts when a commuter indicates their demand on the mobile application. This initiates a request to the central control with the geographic location of the commuter. The central control will combine the location information with other data sources (e.g. traffic, weather, regulations) and provides an instruction to the user.

The instruction would contain the navigation directions to guide the commuter to either a newly created taxi stand or a

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nearby taxi stand. Once the commuter has arrived at the taxi stand the mobile application would send a confirmation to the central control on arrival. Upon confirmation the central control would update its supply and demand information. A queue number will then be assigned and sent to the mobile phone. Information on the updated demand would be disseminated to nearby taxis as necessary.

Our solution consists of two main features. First it allows a real-time and dynamic ecosystem for taxi systems. Commuters can now easily create/join a virtual taxi stand. Resulting in the demand been registered with a central controlling entity. In turn this enables supply provisioning and redirection to the taxi stands to satisfy the demand.

The second feature is that the taxi stands are created based on multiple data sources (road conditions, regulations, weather, demand, etc.). This in turn enables us to influence the travel pattern of both the commuter and taxis thereby helping to improve the traffic conditions accordingly.

Figure 1 is an illustration of how the solution would appear to a normal commuter. It would contain the location and the surrounding virtual taxi stands. The commuter would be guided to the best possible location for a virtual taxi stand taking into consideration the existing queue, route, and traffic information.

The view of a taxi driver is similar to that of a commuter is shown in Figure 2. It would provide the best possible route for the taxi to reach the virtual taxi stand in a timely fashion to pick up passengers there.

Lastly Figure 3 provides an overview for the operators and the authorities. On top of the locations of the taxi stands it also indicates the locations of the available taxis within the region. The demand and supply information at each taxi stand can be pulled up as required.

IV. System Architecture & Process Flow

In this section we will cover on the architecture set-up of our solution and the process at which a commuter indicates their requests for a taxi. An illustration of how we designed the architecture is illustrated in figure 4. The design of the system was done with the focus on augmenting data from various sources in order to achieve the goals of our Virtual Taxi Stand System.

Our system must have the most up to date information about the traffic situation, weather conditions, road regulations and restrictions, and lastly maps and geographic information. We recognize that for there are potentially multiple parties that are providing these information. Therefore rather than implementing them within the architecture, we would work with these data providers to provide us with the relevant information. Such a design would allow us to access the most recent data once it has been changed by the provider. Our design would also allow for extensions to connect with other sources of data such as major events, crowd sourced information, and incidents.

Figure 5 illustrates the process at which the Virtual Taxi Stand System works when commuters expresses their need for a taxi via their mobile devices. The overall process can be split into three main steps Request Processing, Route Planning, and Service Fulfilment.

A. Request Processing

Once the system receives the request from the commuter it activates the Virtual Taxi Stand manager. The Virtual Taxi Stand manager will determine if there is a suitable taxi stand for the commuter. The decision is based on the current landscape of taxi stands, demand and supply, and data from the various external data sources (e.g. traffic conditions, weather, regulations). If a suitable taxi cannot be identified it the manager would then proceed to select the most convenient location to create the next virtual taxi stand.

Creation of the taxi stand is performed based on two main factors. The first is the current distribution of both virtual and physical taxi stands. This is important such that we avoid the situations where virtual taxi stands are created too close to each other.

The second factor is the combination of the external data sources (e.g. weather conditions, geographical information, traffic conditions) and the current demand and requests received from commuters. By factoring these information the newly created taxi stand will strike the right balance between the supply and demand of taxis and commuters.

By the end of this step a taxi stand (existing/newly created) would have been designated for the commuter.

B. Route Planning

Once the designated taxi stand is identified three pieces of information are sent to the commuter. They are the location, suggested route, and the current queue at the taxi stand. The suggested route is computed while utilizing data from external sources. In particular weather conditions as no commuter would be willing to walk in unfavourable weather conditions.

The commuter would be added to the list of arriving passengers until he/she arrives at the virtual taxi stand. Upon arrival at the virtual taxi stand the commuter would perform an acknowledgement action to indicate the joining of the queue.

The acknowledgement action could be done either by updating via the mobile device or interacting with the passenger in front of him. This action will add the commuter into the queue list and removing the entry in the arrival list.

Finally the updated queue information is dispatched to the nearby taxi drivers whom can confirm if they will be providing their service to fulfil the demands. If the taxi driver indicates they would be picking up a passenger a suggested driving route would then be computed and sent to them.

C. Service Fulfilment

Activation of the virtual taxi stand is performed once the queue is formed by the first passenger or the arrival of the first taxi. If it is a newly created virtual taxi stand it would also be updated on the display devices of the taxi drivers on its location. During this phase it is important to keep track if the passengers are still in the queue to ensure the functionality of our system.

Once a passenger has entered a taxi or has chosen to leave the queue we would first update the queue list. Based on the updated queue information and arrival list the system would determine if the virtual taxi stand should be maintained or removed. The status of the virtual taxi stand is determined

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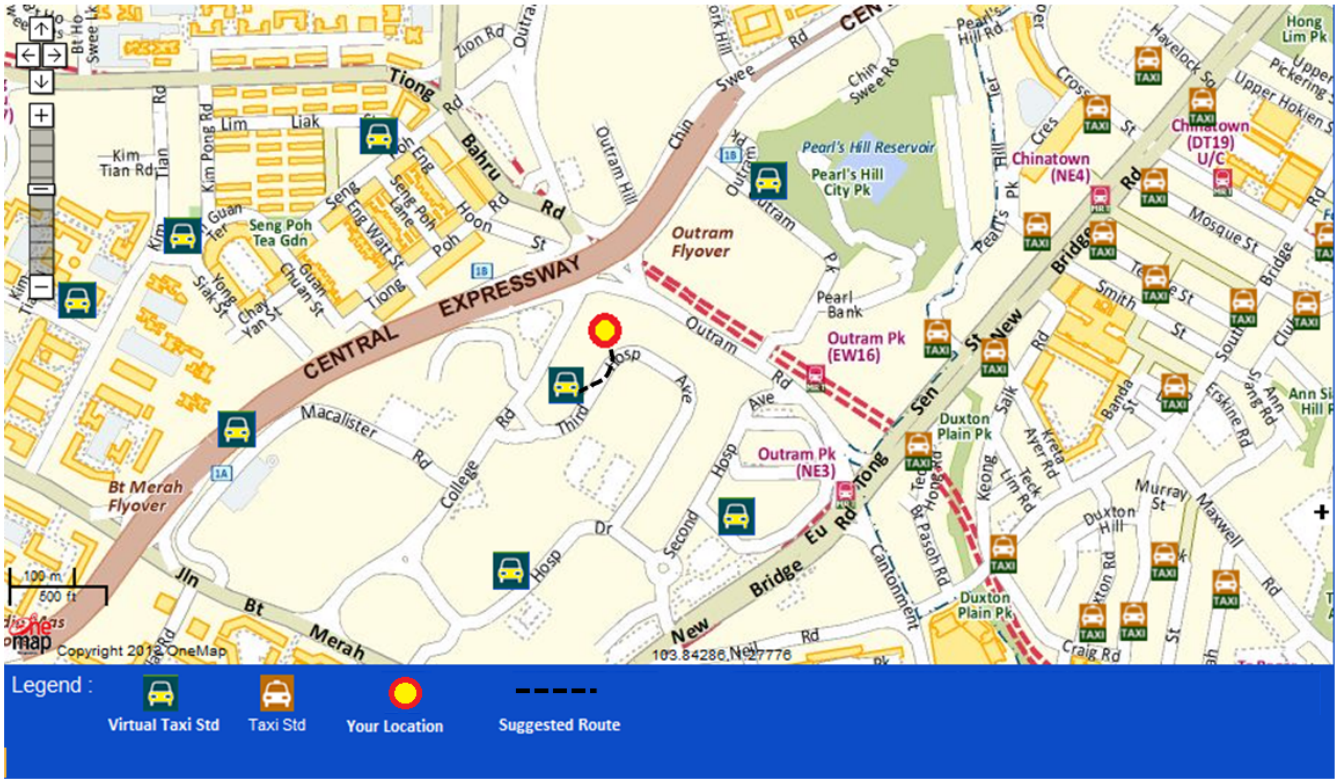

Fig. 1: Information display presented to commuters

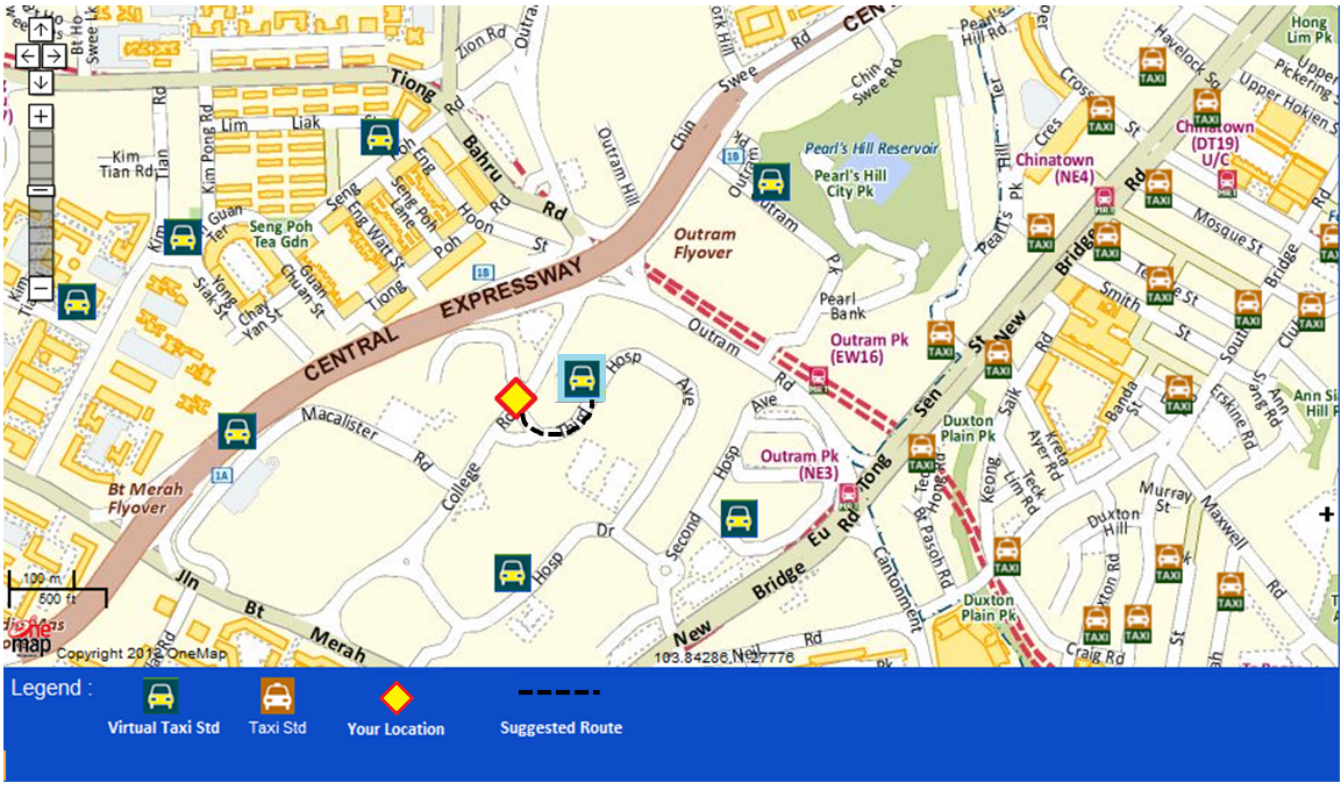

Fig. 2: Routing and map display for taxi drivers

based on the number of commuters in both the current queue and arrival list.

If there are no commuters in the queue and making their way to the virtual taxi stand we would naturally remove the virtual taxi stand from the system. This will also conclude the life-cycle of the virtual taxi stand which is removed once it has satisfied the demands of commuters within the vicinity.

V. Future Works

There remains a wealth of potential in the Virtual Taxi System that would we can explore in our future works. For example the current design of our system does not have the

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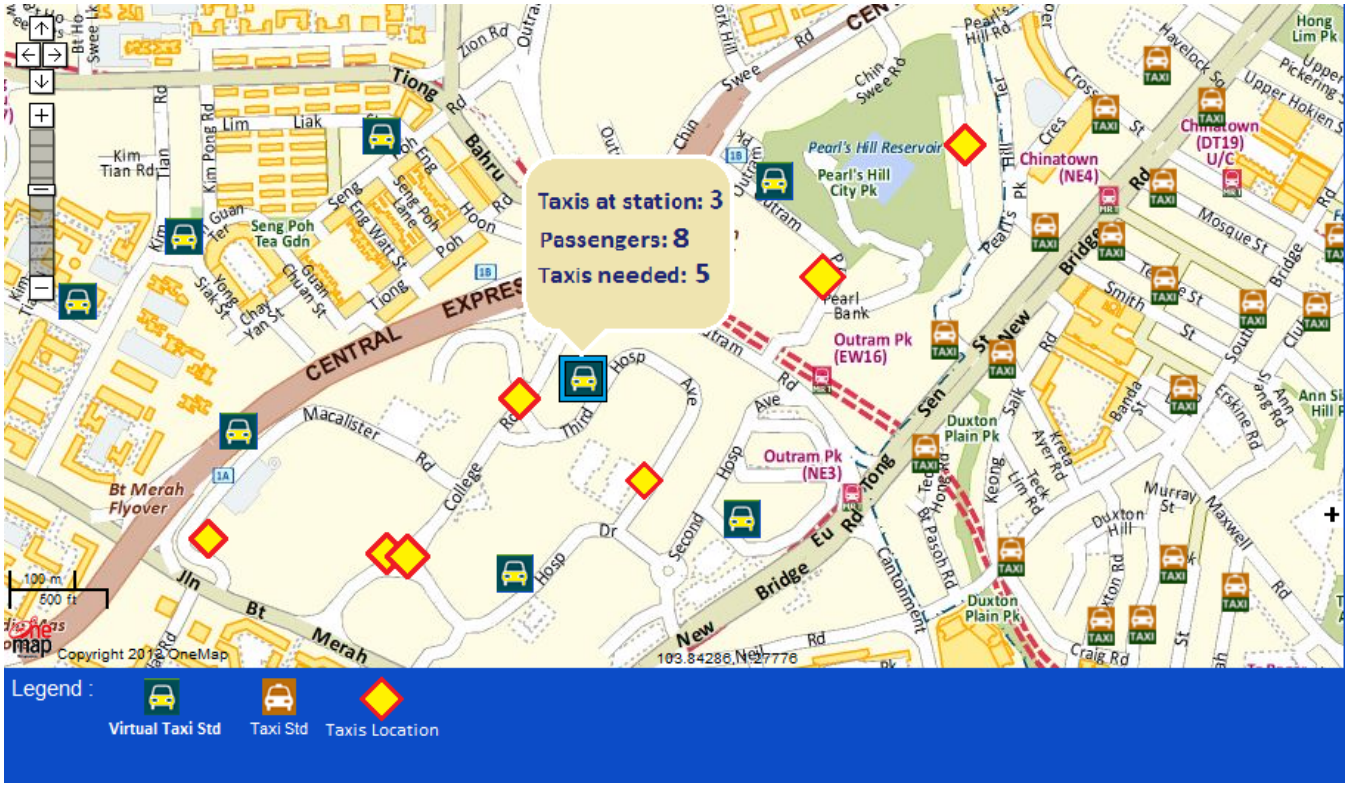

Fig. 3: Interactive view of surrounding landscape presented to Government Authorities and Operators

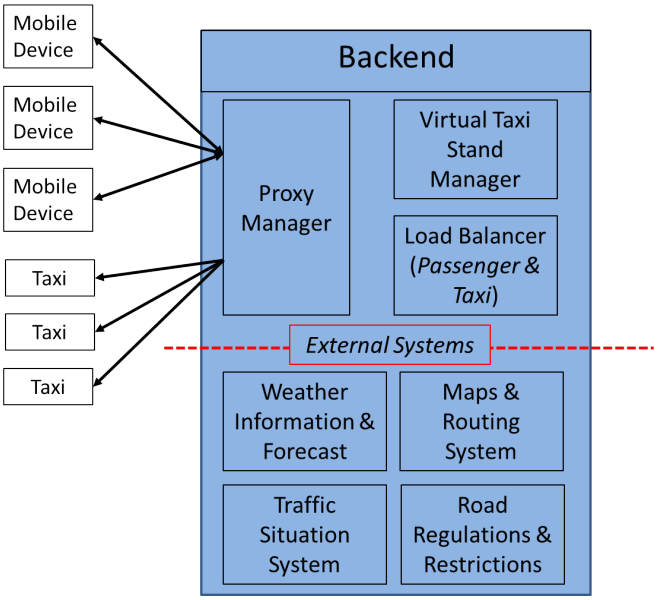

Fig. 4: Virtual Taxi System Architecture

provisions to allow the commuter to make any specifications on their request.

We would expect that commuters would be able to specify information such as the number of co-passengers, type of taxi required (e.g. handicap access, baby friendly, 6 seater), and their destination(s). Such information are commonly requested when making a booking via call centres. The incorporation of such specifications within our solution would increase the usability, coverage, and satisfaction level of the taxi service available.

VI. Conclusion

The widespread adoption and development in mobile technology have increased the ease at which taxi services can be accessed. It has empowers the commuters to better communicate their needs and requirements. Taxi drivers can also better understand the available passengers. Existing solutions have focused on the individual level where they deliver highly personalized solutions to both the commuters and taxi drivers.

Our solution seeks to elevate the level of communication and existing service level by providing a new paradigm. The virtual taxi stand solves the problem by the central control directing both the commuter and taxi to a common location introducing several benefits to the ecosystem.

Taxis have the benefit of been guided to the nearest virtual taxi stand once it becomes available. This in turn means an increase in their revenue through a better utilization rate. The virtual taxi stands are created based on information regarding weather, traffic, and regulations. Thereby creating a safe and optimal location to pick up a passenger. Taxi drivers no long have to worry about violating any road regulations or causing any traffic slowdown when picking up passengers by the roadside.

Commuters now can save time spend waiting on the phone to get through to the operator or to wait for a taxi to be assigned. In addition they would also avoid having to pay for any fees associated with the booking service. We also solved the issue where commuters have to walk to locations where they know taxis are likely to drive pass or move to the upstream of the traffic. At the taxi stand they can have a better expectation on the waiting time required based on the queue. The transparency of such information has immense impact on improving the experience and satisfaction of the

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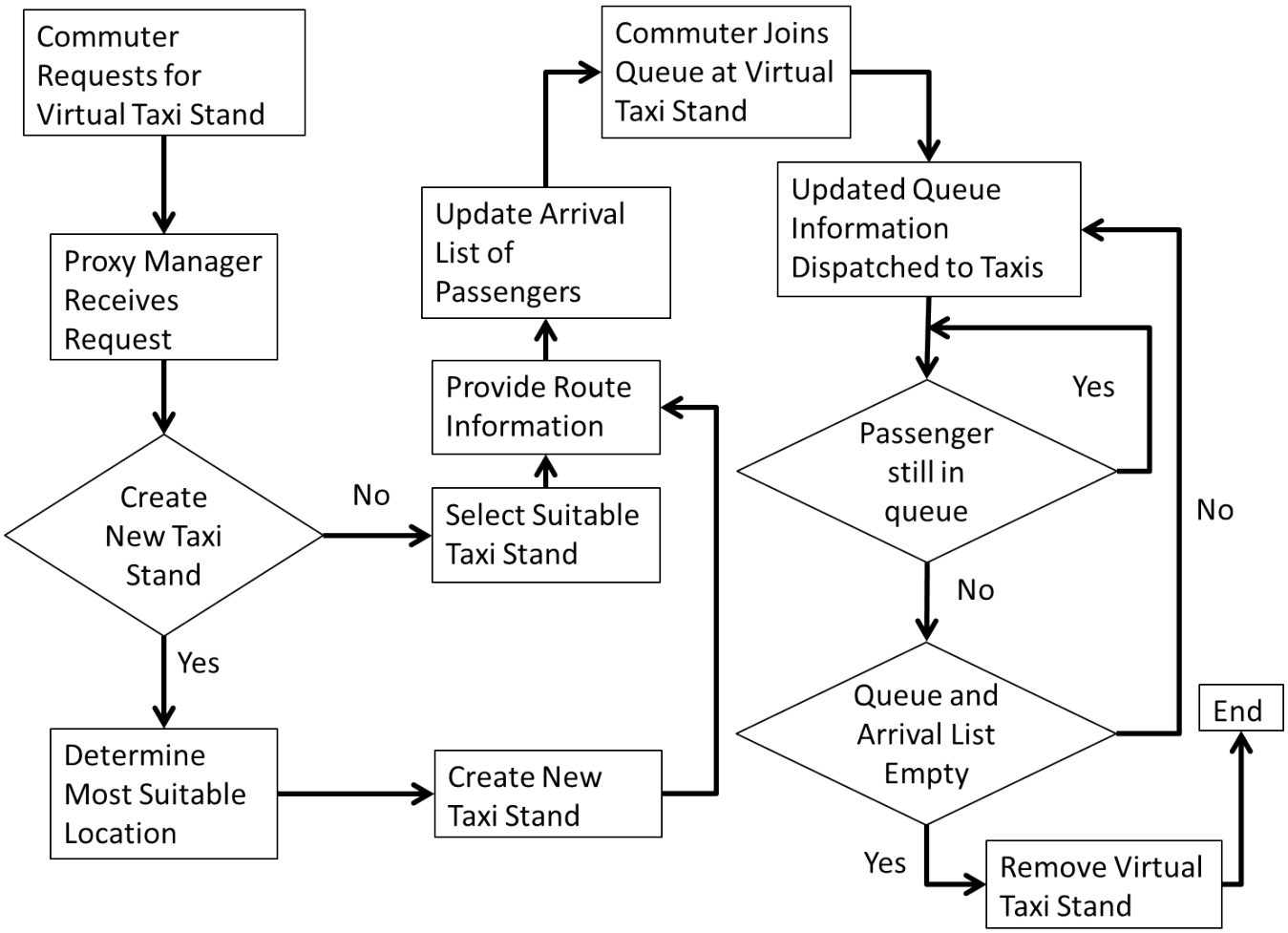

Fig. 5: Process Flow of the Decision System

commuter.

Lastly through a central control system the length of the queue at the taxi stand can be better managed. Based on the amount of demand received for a location we can create taxi stands which help in distributing the commuters to various locations. This is a vast improvement over existing physical taxi stands where long queues and bottlenecks are commonly found.

All our aims and objectives are achieved through the central control system which runs behind the scenes. We have a holistic solution which encompasses data sources such as weather, regulations, and traffic which are relevant to the ecosystem. Demand and supply are distributed based on a load balancing algorithm making use of the data sets. A resource optimization algorithm is then used to provide recommendations of navigation directions to between commuters and taxi drivers.

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