

# Parcel Lockers for B2B Distribution in Central Business Districts

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***Abstract:*** *E-commerce has led to more small parcels being shipped between businesses in metropolitan and CBD areas. Courier routes in large metropolitan areas are inefficient due to the long stem distances and prevalence of courier companies only operating from a single depot.*

*This paper presents a model for estimating the benefits in terms of reduced distances travelled by courier vans when a shared system utilising parcel lockers is used for CBD based deliveries. The model was used to predict the savings in distances travelled by courier vans when operating in a shared system utilising parcel lockers. Substantial savings in travel distances were estimated that would reduce vehicle operating costs as well as improving sustainability.*

***Keywords:*** *Parcel lockers; couriers; hyperconnected city logistics; multiple modes.*

## 1 Introduction

Parcel lockers provide many benefits for last kilometre deliveries. This paper describes the development of tools for designing and evaluating networks of shared parcel lockers for Business-to-Business (B2B) courier deliveries to Central Business Districts (CBDs). Using principles associated with the physical internet such as shared and collaborative networks this paper describes how various modes (including walking and bikes) can be integrated to reduce the financial and environmental costs of delivering and collecting parcels.

E-commerce has created many challenges for urban distribution systems. Businesses in CBDs often request delivery of small consignments at diverse locations. The growth in parcel deliveries to offices and retailers in CBDs, with traditional delivery modes, is leading to more traffic congestion in central city areas. Increased pedestrianised areas, competition for parking spaces and disruption due to construction activities is creating substantial efficiency and sustainability challenges for couriers.

City planners are increasingly looking to design cities for "people and places" and less for cars/vehicles. Construction traffic is one of several disruptors and in the scheme of things it has a short-term impact in a particular location. While the challenges for effective management of urban freight are increasingly dynamic and complex, the applications of collaborative transport and logistics promise enormous benefits in tackling the inherent efficiencies exist in distribution of goods in cities. In particular, in the light of rapid growth in the implementation of data analytics and Internet of Things (IoT) practices within transportation context, the opportunities for development of sustainable and cost-effective city logistics models which benefit from shared resources are limitless. Given the soaring demand for such approaches, this paper proposes a model to evaluate the savings in terms of distance travelled by courier vans when a system of shared parcel lockers is utilised for CBD based deliveries.

# 2 Hyperconnected city logistics

Hyperconnected City Logistics (HCL) is an emerging concept based on the physical internet that involves improved management of goods in urban areas using transfer facilities such as loading docks and parcel lockers (Crainic and Motreuil, 2016). HCL consists of an integrated network of consolidated containers, transhipment nodes and delivery means using a shared network of nodes, that can include Urban Consolidation Centres (UCCs) and Cross Docking Centres (CDCs) as locations for shared parcel lockers.

Information requirements for designing HCL networks include determining the:

(i) ideal location, size and function of nodes,

(ii) capacity: in terms of types of vehicles servicing nodes, and

(iii) equipment for transferring containers.

The information requirements for network operations relate to developing schedules (frequency and timing) to coordinate transport services.

# 3 Parcel lockers

Parcel lockers are traditionally associated with e-commerce as a viable alternative to home deliveries for B2C consignments. The Benefits, particularly in reducing futile home deliveries are welcome by couriers and can be substantial (Iwan et al., 2016). E-commerce, especially B2B, continues to grow at increasing rates, and there is a need to develop more efficient and sustainable processes to cater for the rising levels of demand and provide high levels of service. Parcel lockers provide a flexible option for transferring goods between different modes within the courier process of B2B deliveries and they can provide substantial financial savings for carriers as well as social and environmental benefits (Thompson and Taniguchi, 2015).

The supply of parcel lockers relates to the location of banks as well as the number and size of lockers within them. Models are required to determine the best location for locker banks including sites near offices and shops. To maximize the potential of parcel locker systems for improving the efficiency and sustainability of last kilometre freight it will be important that open systems are created where lockers can be shared by multiple logistics organizations. Shared parcel locker systems allow integrated multi-modal B2B logistics networks to be created.

Parcel lockers provide an opportunity to transfer goods between modes and logistics partners. Trucks and vans can be used to carry parcels to locker banks and these can then be picked up by couriers to delivery to the final customers within a precinct or area of the CBD. Walking and cycling can often be more productive in conducting deliveries in central city areas. The courier hub facility in Sydney has a set of lockers that can be used to exchange goods between carriers and vehicle modes (Stokoe, 2017).

# 4 Networks

## 4.1 Courier networks

Existing courier networks typically involve each courier acting independently and performing routes to pick up parcels from all the origins of their customers tasks in the outer area and then undertaking a tour to drop off parcels to all the destinations of their customers in the inner area (See Figure 1).

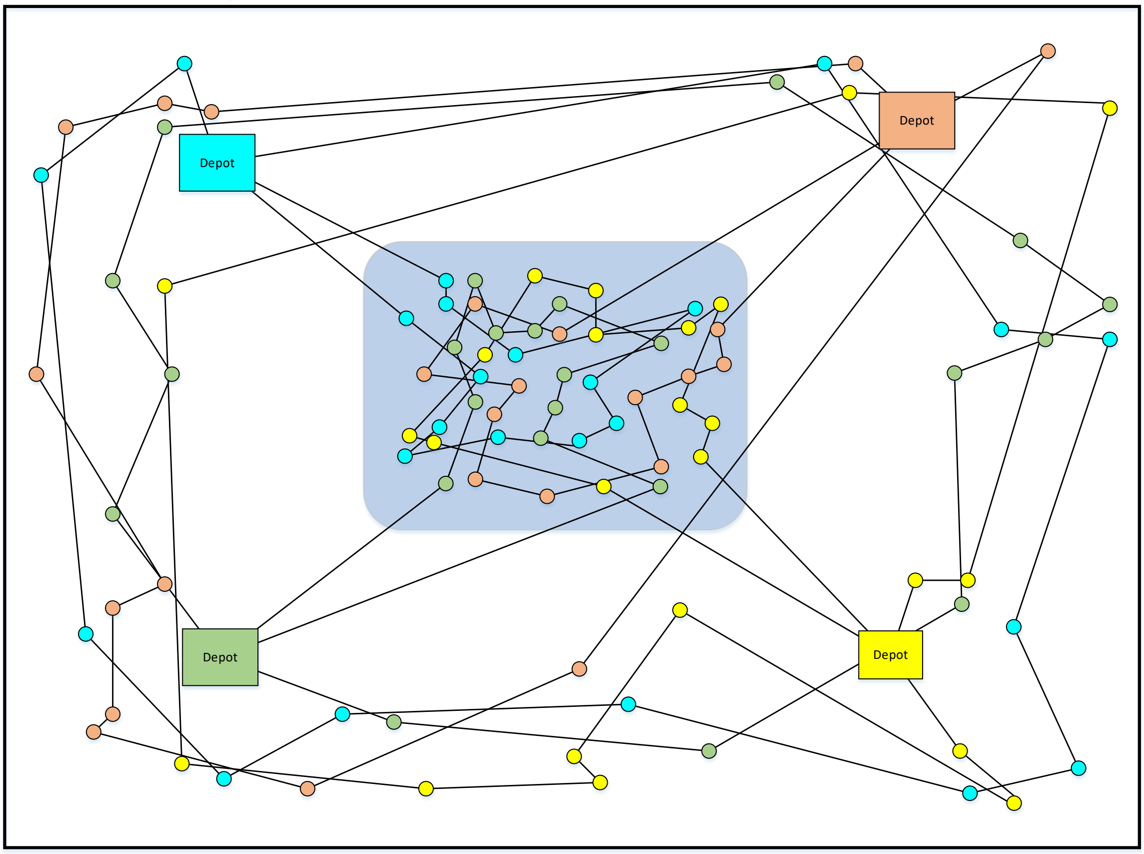


*Figure 1: Existing CBD courier network*

## 4.2 Hyperconnected city logistics (HCL) based networks

Within an HCL network each courier can participate in a joint service. This can involve performing a route to pick up parcels from all origins of customers tasks near their depot as well as delivering them to a locker bank located near or within the CBD, and then undertaking a route from this locker bank to deliver to nearby receivers in the inner area (See Figure 2).

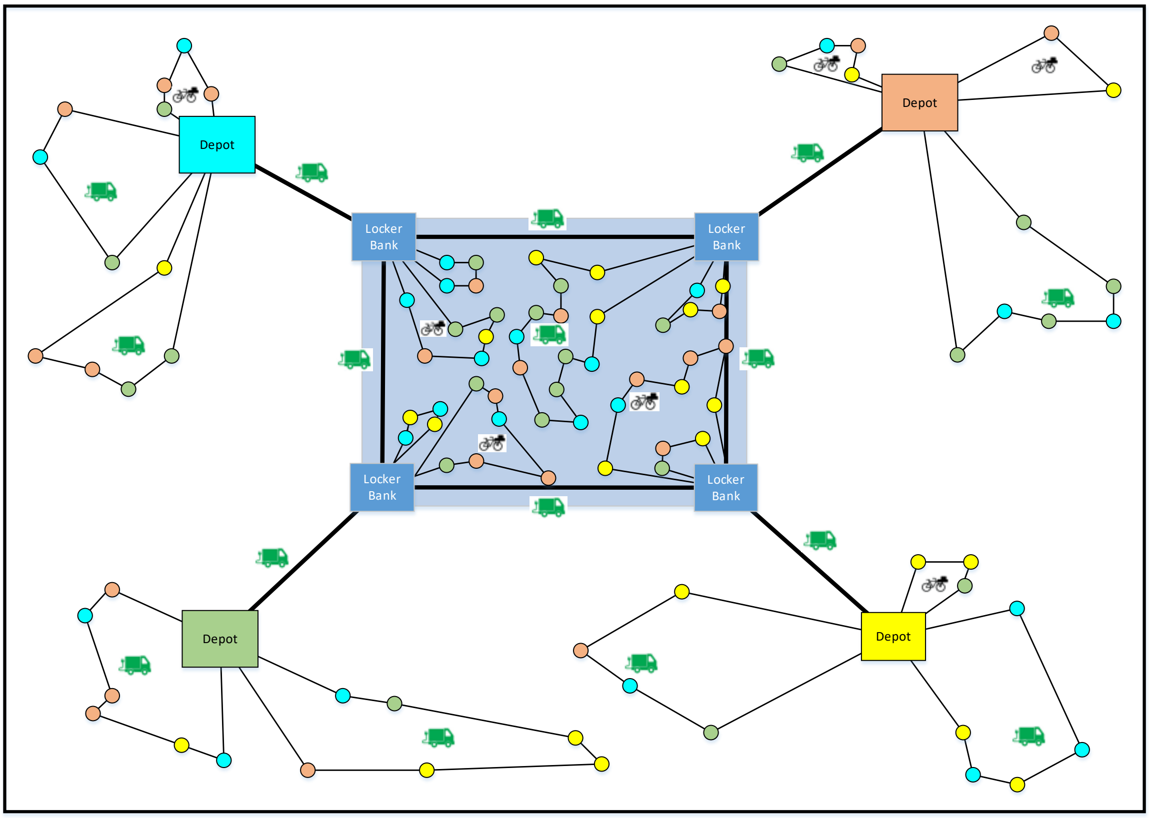


*Figure 2: Potential HCL CBD courier network with parcel lockers*

## 5 Model development

A model was developed to estimate the savings in distance travelled using a shared parcel locker system. A hypothetical urban area of 20km x 20km consisting of 25 zones (each 4km x 4km) and a centrally located CBD (1km x 1km) consisting of 25 zones (each 200m x 200m) was used (Figure 3). Each of the four courier companies has one depot located in one corner of the urban region (triangles in Figure 3). Parcel pickups are from within the urban area and drop-offs within the CBD (Green square in centre of Figure 3).

Distances to and from zones were calculated using the Manhattan distance between the location of depots and centroids of zones. A continuous approximation model was used to estimate the distances travelled while performing the pick-up and drop-off routes within zones (Daganzo, 1984).

The daily demand for each courier was 400 customers with an average of 1.5 parcels per customer. The capacity of courier vans was set at 30 parcels.

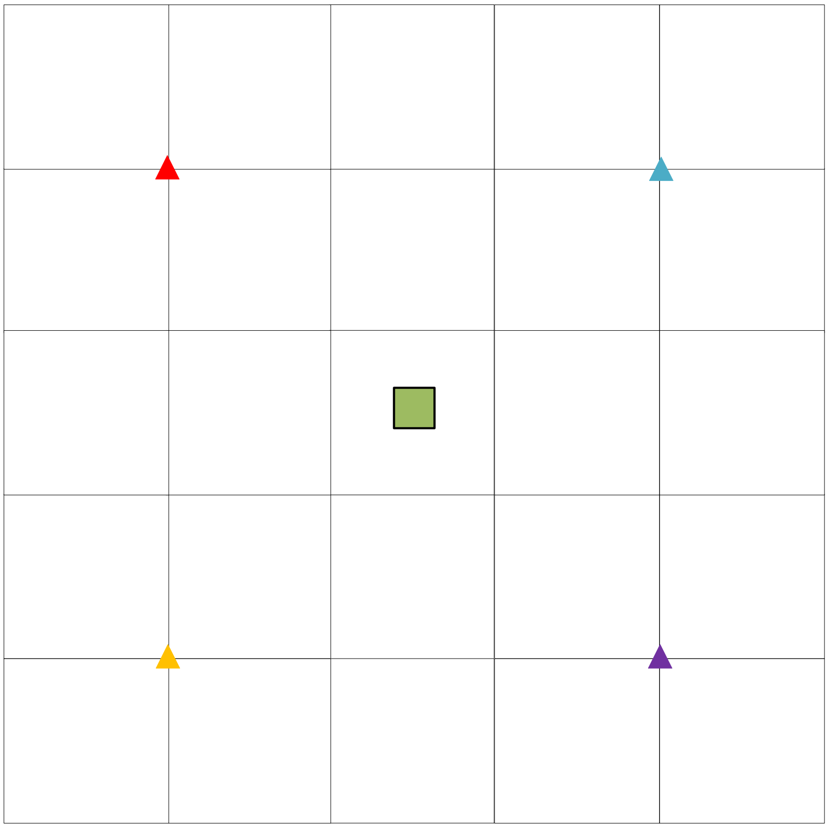

*Figure 3: Metropolitan area and CBD*

### 5.1 Estimation process

The model for estimating the distances travelled by vehicles requires data relating to the demand and capacity of vehicles as input. The number and size of zones for courier routes were then determined based on vehicle capacity. The number of vehicle routes within a specified time period is then determined.

The time taken to complete routes consists of loading/unloading times at the depot, service times at each customer, travel times between the depot and customers as well travel times between customers. Parameters used are shown in Table 1.

*Table 1: Route parameters*

| | |
|---|---|
| Average vehicle speed: Urban area (km/h) | 40 |
| Average vehicle speed: CBD area (km/h) | 30 |
| service time at each customer (min.) | 2 |
| Walking between vehicle & customers (min.) | 2 |
| Loading/Unloading of vehicle at depot (min.) | 30 |

### 5.2 Independent networks

As a base case, each courier company was assumed to operate separate routes for picking up and delivering parcels throughout the urban area. Pickup routes involve courier vans travelling from their depot to shippers within the urban area and then returning to their depot with parcels. Drop-off routes involve courier vans delivering parcels from their depot to receivers in the CBD.

Demand was presumed to be uniformly distributed within the urban area, allowing each van to perform one pickup route within each urban zone. Based on the distances travelled for each route, some drivers could undertake multiple routes within a four-hour shift. The total distance travelled for pickup routes for each driver shift for each delivery company was estimated to be 928km with a combined total of 3,712km for all the four courier companies (Table 2). Based on average speed of 40km/h for courier vans and a maximum route time (including driving and servicing times) of 4 hours it was estimated that a total of 13 driver shifts would be required to undertake the pickup routes within the urban area to each depot.

Vans were also assigned drop off routes within the CBD zone. Demand was assumed to be uniformly distributed within the 25 CBD zones, with each van having sufficient capacity to complete all the parcel drop-offs within a CBD zone in one route. However, due to the long steam distance of the drop-off routes between the depots and the CBD zones, only 2 routes for each van could be completed within a four-hour period. Thus 13 driver shifts are required for each courier company to perform the parcel drop-offs from their depot to the CBD zones.

## 5.3 Shared parcel locker networks

The shared system involves each courier company picking up parcels from urban zones near their depot (Figure 4), transferring the parcels from their depot to locker banks in the CBD and then conducting drop-off routes from the parcel lockers to customers in the CBD zones.

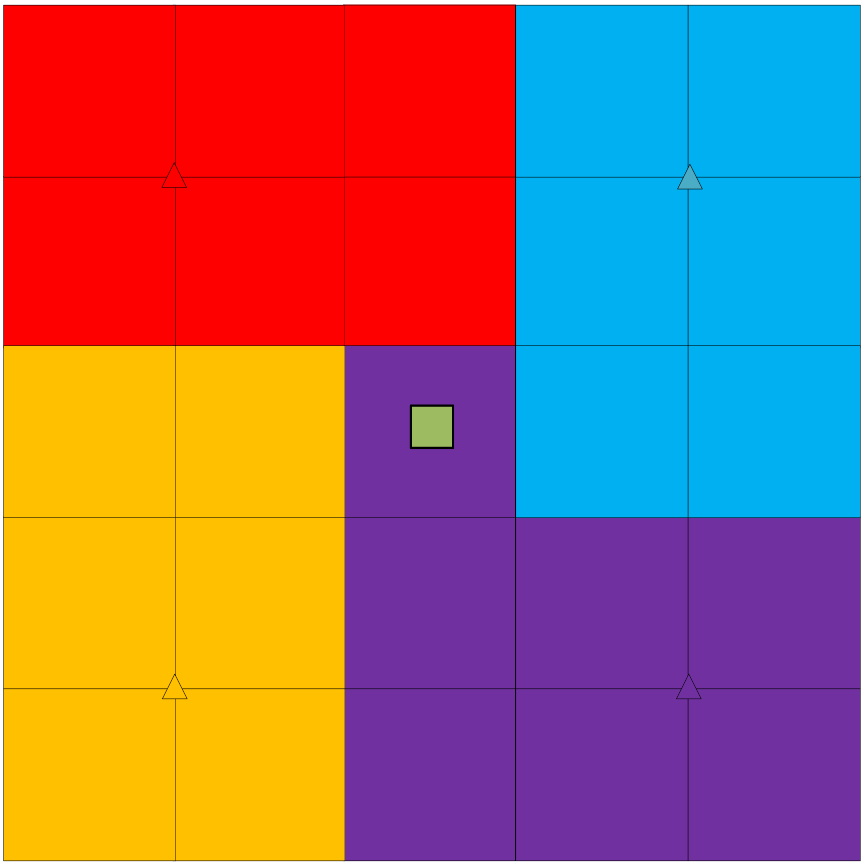

*Figure 4: Local Pick-up zones for shared system*

Vehicles from each depot perform a shuttle between depots and the 4 parcel locker banks within the CBD area. Parcels are transported to the parcel locker that in close proximity to each drop-off customer. Parcels are then distributed to customers in the CBD zones from the parcel locker banks. The shared system involves each courier company conducting drop-off routes from one of the parcel locker banks to 6 or 7 CBD zones near each locker bank. The capacity of the vans allows 1 route to be undertaken for each CBD zone.

A summary of the distances travelled by vans for both the independent and shared networks are shown in Table 2. Considerable savings in total distances travelled by van are achieved using a shared system.

*Table 2: Distances for courier routes*

| | Independent (km) | Shared (km) | Saving (km) | Saving (%) |
|---|---|---|---|---|
| Pickup → Depot Metro Area | 3712.0 | 528.0 | 3184.0 | 85.8 |
| Dropoff → CBD Area | 2447.2 | 505.8 | 1941.4 | 79.3 |
| TOTAL | 6159.2 | 1033.8 | 5125.4 | 83.2 |

For the independent system, 13 vehicles are required for driver shifts with multiple routes for metropolitan pick-up routes as well as deliveries to the CBD zones based on maximum route duration of 4 hours.

For the shared system, 13 vehicles are also required for driver shifts with multiple metropolitan pick-up routes, however 5 vehicles are required to perform the shuttle service between each depot and each parcel locker within a three-hour period, therefore a total of 20 vehicles from each courier company is required. Only 4 vehicles are required for driver shifts for routes from each parcel locker.

Considering the number of parcel lockers at each locker bank, since there is only 1 route from each parcel locker to each CBD zone to drop-off parcels, all parcels must be at the locker bank before the CBD drop-off routes can be commenced. Thus, each locker bank needs to be able to accommodate 600 parcels (1/4 of the total demand) and requires an area of $60m^3$ if parcels are on average $0.1m^3$. This is equivalent to a moderate sized room (e.g. 5m x 4m x 3m).

## 6 Conclusions and future work

A shared courier distribution system for delivering small parcels from a metropolitan area to a CBD utilising locker banks has been evaluated. A model was used to estimate the savings in distances travelled by vehicles. Overall the shared system was predicted to substantially reduce vehicle operating costs as well as improve sustainability.

The shared courier system introduced in this paper could be varied to consider utilising non-motorised transport modes, especially within the CBD area. This would change the times required to undertake deliveries. The model could also be used to investigate how much less travel distance would be achieved if larger vans or trucks were used for the shuttle between depots and parcel lockers.

It would be useful to incorporate financial modelling to consider the potential revenue and costs associated with setting up and operating the locker banks.

The model could also be extended to minimise the total costs for both carriers as well as locker bank owners and managers considering synchronisation of vehicle arrivals and departures from locker banks to reduce the number of lockers required. This would involve the shuttle runs feeding locker banks from depots. Further studies could also investigate the potential savings in joint delivery of parcels between couriers within urban and CBD areas.

The implementation of such practices by couriers could potentially unlock significant benefits in terms of distribution costs and lower number of vehicles used for performing the same task.

## References


- Crainic T., B. Montreuil (2016): Physical internet enabled Hyperconnected City Logistics,