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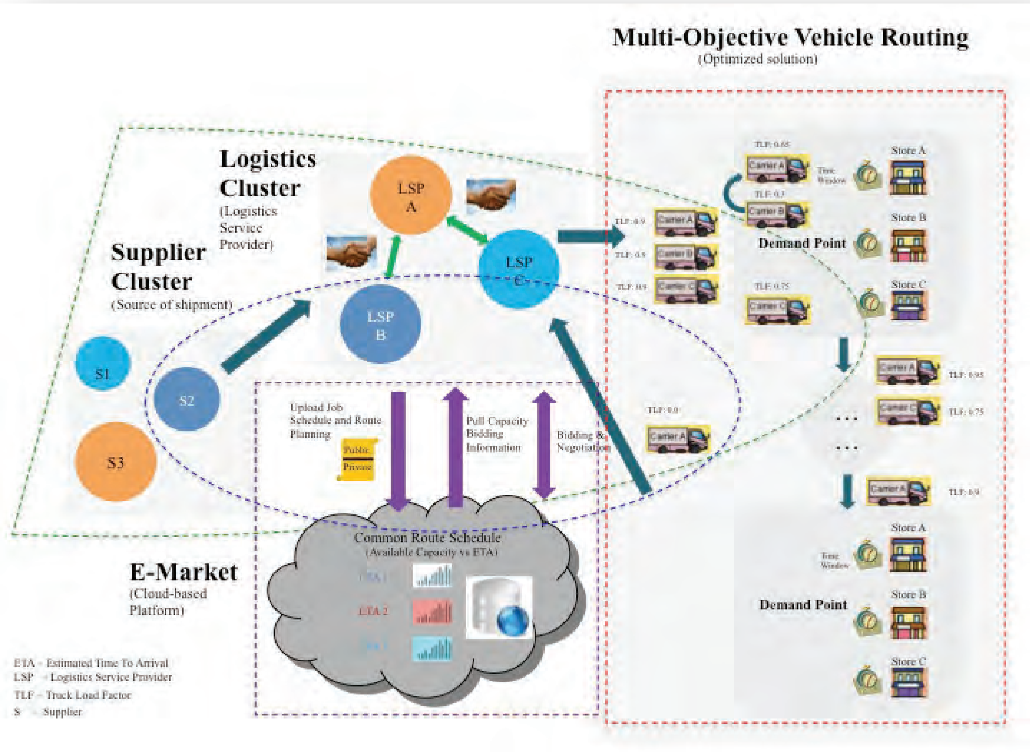
COLLABORATIVE URBAN LOGISTICS:

Synchronized Last-Mile Logistics for Sustainable, Efficient Urban Delivery

Volume 13-Nov-CUL



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The Last Mile – The Next Stage of Research

11 NOVEMBER 2013

SINGAPORE

Synchronized Last-Mile Logistics for Sustainable, Efficient Urban Delivery

INTRODUCTION

Last-mile logistics is an emerging field of investigation into the synchronization, management and optimization of urban freight transport and distribution systems. This last leg may face significant fulfillment constraints, higher social, environmental and economic costs, making it the most expensive and polluting part of the chain.

Collaboration between stakeholders comes as an alternative solution for last-mile logistics to improve efficiency, sustainability and responsiveness.

Stakeholders in last-mile logistics are diverse and manifold: industry stakeholders in supply, manufacturing, transportation and retail in the urban space; different layers of government; and road traffic participants, retail consumers, and communities in the broader urban society. Each stakeholder has its own interest which most of the time are conflicting. These interests introduce major challenges which we categorize into two groups: externality and business challenges.

To handle the externalities and business challenges, stakeholders implement their own strategies by optimizing travelling time and load capacity usage for cost efficiency. Unfortunately, these individual efforts may result in a lose-lose situation where the efficiency of a company is achieved at the expense of others and which does not seem sustainable in the longer-term. Collaboration (cooperative or competitive) between stakeholders comes as an alternative solution for last-mile logistics to improve efficiency, sustainability and responsiveness.

EXTERNALITY

It is common practice for stakeholders in last mile logistics to pursue their individual strategies to improve business development cost efficiency and maintain service levels in delivery operations by optimizing travel time and load capacity usage. Unfortunately, these efforts may result in lose-lose situations, where short-term efficiencies of individual companies are achieved at the expense of the long-term sustainability of the urban freight transport system.

In economics, this situation is termed an 'externality' where the activity of one or more stakeholders impacts the 'welfare' of the other stakeholders, outside of the market mechanism[1]. A brief summary of externalities in the last-mile logistics cost and benefit context is presented in Table 1. A graphical representation of the externality problem in freight transportation

[1] F Ranaiefar and A Regan, "Freight-Transportation Externalities," in *Logistics Operations and Management: Concepts and Models*, ed. Farahani R, Rezapour S, and Kardar L(Elsevier, 2011).

using a cost-demand graph is drawn in Figure 1. The Marginal Private Cost (MPC) is the cost to the stakeholder of delivering a given good or service. Each stakeholder is trying to minimize its MPC by improving its individual efficiency which unfortunately may result in negative externalities such as pollution or congestion, creating industry inefficiencies ('deadweight loss') that shifts the MPC to its true Marginal Industry Cost (MIC).

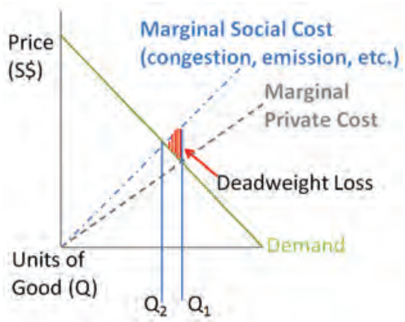


Figure 1. Externality Problem for Freight Transportation

Table 1. General last mile logistics cost and benefit specification

Cost	Description	E/I	V/F	M/NM
Vehicle ownership	Vehicle expenses not proportional to distance	I	F	M
Vehicle operation	User expenses proportional to distance	I	V	M
Vehicle coordination	Expenses for planning and managing vehicle fleets	I	F	M
Operating subsidies	Vehicle expense not paid by user	E	V	M
Reliability risk	Cost for delay likelihood	E	V	M
Congestion	Increased delay, costs, stress	E	V	NM
Benefit	**Description**	**E/I**	**V/F**	**M/NM**
Income	As provided to firms and their employees	I	V	M
Reputation	Reliability and social responsibility	I	F	NM
Access to goods	Reliable access to a variety of goods	E	V	NM
Supply Chain Effectiveness	Last mile reliability benefits entire chains	I	F	M
E = external cost; I = internal cost; F = fixed cost; V = variable cost; M = market cost; NM =nonmarket cost				

Adapted from Ranaiefar and Regan (2011)[2]

Managing Externality

Left to the stakeholders' individual devices, the generated externalities will end in a 'market failure' – a situation where last mile deliveries fail to attain a socially acceptable optimal level i.e. resulting in the inefficiency and inequality of allocation of resources. Cooperation amongst the stakeholders can lead to positive externalities – a situation where additional benefits are received by 'society' as a whole while competitive behavior, unmanaged, can result in negative externalities such as pollution and congestion.

Economists suggest incentivizing behavior toward a positive 'global' outcome and 'taxing' out inefficiencies that run contrary to the desired globality. In this white paper, we discuss the modes of incentives (and disincentives) through visualization, coordination and cooperation, data sharing, shared fleets and an integrated marketplace that trades off inefficiencies whilst simultaneously increasing responsiveness and sustainability.

[2] Ibid. Page 1.

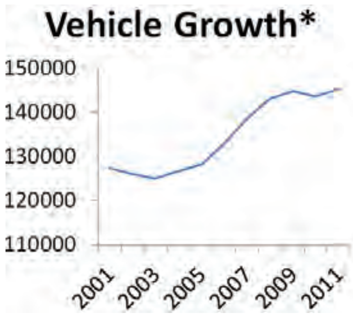
BUSINESS CHALLENGES

Today, more than ever, customers have specific requirements of how products and services are supplied and delivered to their door steps. Last-mile logistics as a customer's last point of contact must react to this change with real-time solutions that can be readily adapted and applied. At the heart of the challenge in the last mile is efficiency, sustainability and responsiveness.

Efficiency

The unit costs of the last-mile are usually higher than those in other logistics activities and are estimated to be between 13% and 75% of the total logistics costs, depending on the industry. The main factor of this high cost is the underutilization of truckload capacity. As reported by van de Klundert and Otten (2011)[3], in Europe, the average truck utilization is below 50%, while in the US, the empty line haul miles account for a large percentage of the 80 billion dollar wasted in the transportation sector, which is more than 10% of the total revenue.

In Singapore, the number of vehicles (for goods and others vehicles) is increasing every year[4] as illustrated in Figure 2. But vehicle growth is not a guarantee that truckload is fully utilized.



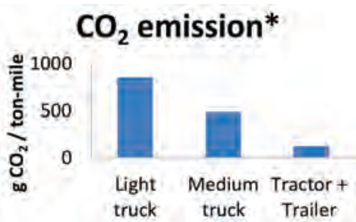
*: for Goods and Other Vehicles
Source: Land Transport Authority, Singapore

Figure 2. Vehicle Growth

Sustainability

Environmental concerns are becoming increasingly important to logistics service providers. In the urban setting, last mile logistics presents two major environmental issues: road congestion and CO_2 emission. Road congestion has become one of the inconveniences of modern life that escalate travel time not only for logistics service providers but also for the urban society as a whole. With an increasing number of vehicles (as shown in Figure 2), the congestion level is escalating. Congestion, in turn, also increases CO_2 emission.

According to the Singapore National Environment Agency, Singapore emits about 40,000 kilotons of CO_2 each year, 19% of which is from transportation[5]. Different freight transportation has different standard emissions factors as presented in Craig et al. (2012)[6]. Figure 3 displays the standard emissions factor per ton mile used calculated using the GHG Protocol Defra that makes use of survey data to estimate fuel efficiency and the average load factors by freight transportation type[5].



*:calculated using GHG Protocol (Defra)
Source: Craig et al. (2012)[5]

Figure 3. Standard CO_2 Emissions Factor

Responsiveness

With the growth in the retail and e-commerce markets as shown in Figures 4 and 5 respectively[7], companies need to improve their responsiveness in handling the high demands of products and services. The problem becomes worse when retail and home-delivery customers prefer to accept their delivery in a certain time window. Companies need to meet these strict time windows to maintain the desired service levels.

3 J Van de Klundert and B Otten, "Improving LTL Truck Load Utilization on Line," European Journal of Operational Research 210, no. 2: 336-343 (2011).
4 Land Transport Authority, Singapore. http://www.lta.gov.sg.
5 National Environment Agency, http://www.nea.gov.sg/ar07/climate-highvolt.html.
6 A J Craig, E E Blanco, and Y Sheffi. Estimating the CO_2 intensity of intermodal freight transportation. In ESD Working Paper Series. Massachusetts: Massachusetts Institute of Technology (2012).
7 EuroMonitor International, http://www.euromonitor.com.

THE 'SYNCRONIZED LAST MILE' CONCEPT CREATED

In meeting the organizational challenges of improving individual efficiency and responsiveness, individual stakeholders' actions may not result in sustainability improvement. Collaboration between stakeholders enables the solving of problems that one stakeholder cannot solve alone and creates benefits to all collaborating stakeholders.

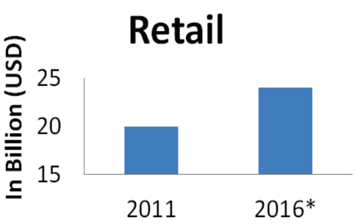
To encourage collaboration, a holistic and comprehensive analysis tool with real-time solutions that can be readily adapted and applied with features to: (1) visualize the demand, (2) manage coordination and collaboration, (3) provide a dynamic delivery schedule, and (4) establish an interaction space for all stakeholders, is needed to deliver substantial improvement in last-mile logistics synchronization across stakeholders.

Visualization and Analytics

A geographical visualization tool allows the stakeholders to visualize key information (such as demand) to provide (operational) insight to industry stakeholders (e.g. retailers, LSPs and authorities). The main purposes for visualization are:

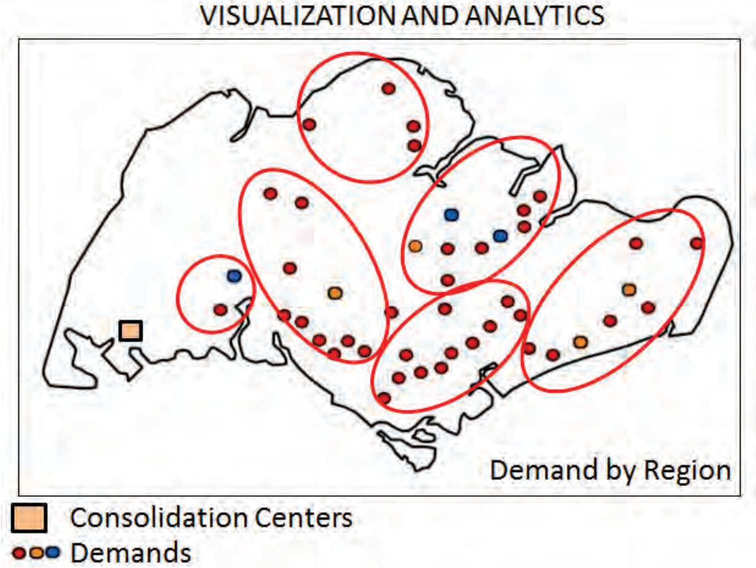
1. To map demands based on user categories (such as: regions and type of goods).
2. To analyze supply chain network flows to provide better insight and deliver opportunities to craft an efficient and responsive strategy for improvement of the overall last-mile logistics process.

Data analytics provide companies with the ability to exploit real-time information for dynamic supply and demand coordination, finding hidden opportunities, dash boarding key performance indicators and collaborative synchronization. Additionally, data analytics is employed in generating and interpreting business intelligence reports to monitor the operational status.



*: estimation
Source: EuroMonitor International

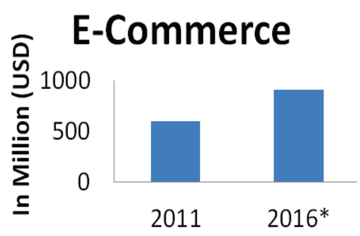
Figure 4. Growth of Retail Markets



Adapted from: FairPrice Store Location[8]

Figure 6. Visualization and Analytics

[8] FairPrice Store Location. http://www.fairprice.com.sg.



*: estimation
Source: EuroMonitor International

Figure 5. Growth of e-Commerce Markets

Multi-Objective Coordination and Collaboration Management

Last-mile logistics, especially in the collaboration context, considers several potential trade-offs between competing objectives, such as to meet demands and service level and to reduce both operational costs and environmental impact costs. This is constrained by delivery time demands, personalized quality services that are expected by customers and compliance to contracts and regulations. In a coordination and collaboration management system, these often conflicting objectives are managed using three main functions:

1. Multi-objective resource scheduling that aims to provide resource scheduling and demand allocation with regards to each stakeholder's objectives.
2. Service level and contract performance management and analysis that aims to design a formalized service level contract that standardize the expectation and information sharing between stakeholders.
3. Simulation and interaction with the urban freight system that aims to model the sensitivities of the elements in last-mile logistics content to provide a better understanding of their service level.

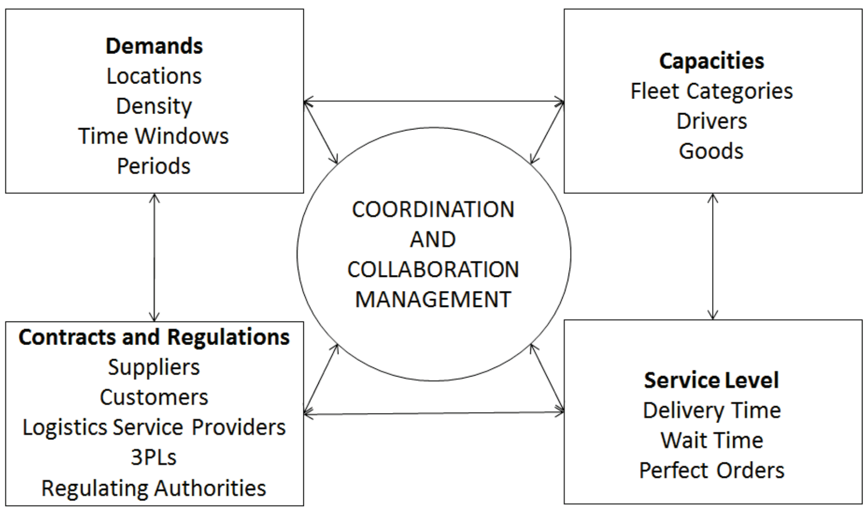


Figure 7. Coordination and Collaboration Management

Dynamic Scheduling and Routing

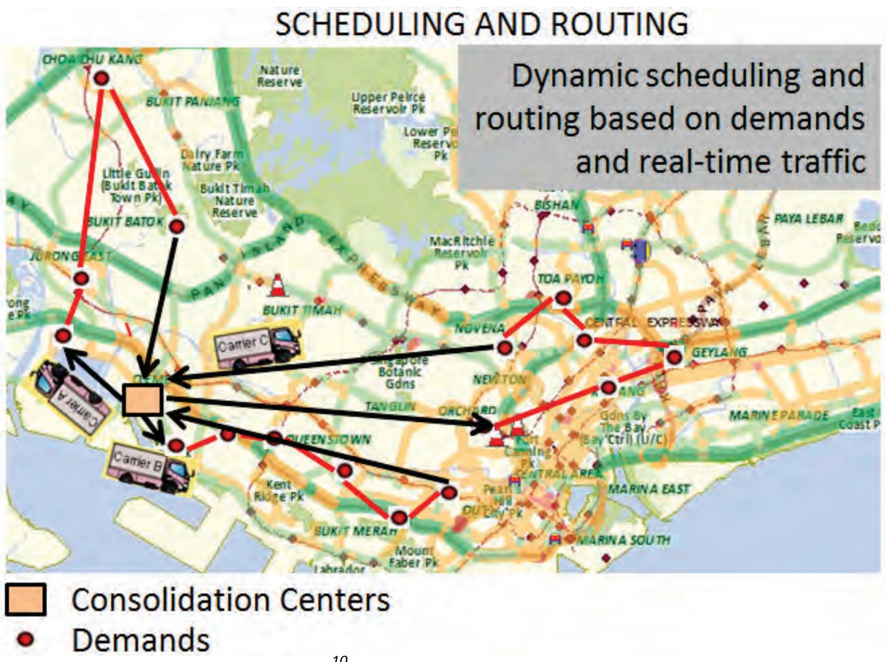
The utilization of truck resources is a major challenge in last-mile logistics. Stakeholders in last-mile logistics must schedule and route deliveries based on customer demands and requirements, but stakeholders are also constrained by their vehicle capacity and freight requirements (e.g. cold container). There are basically three schemes for vehicle ownership: (1) private fleet ownership, (2) outsourced fleets, and (3) shared fleets.

Private ownership and outsourcing provide flexibility at the expense of an increased transportation cost. However, it may introduce problems with expanding network demand. Shared fleets may provide an alternative solution that does not only reduce the transportation cost (around 40% according to Barceló et al. (2011)[9]) but also reduces traffic congestion and CO_2 emission.

There are basically three schemes for vehicle ownership: (1) private fleet ownership, (2) outsourced fleets, and (3) shared fleets.

Regardless of the vehicle ownership scheme, a scheduling and routing plan is needed. Dynamic scheduling and routing helps to optimize the fleet travel time while fulfilling customer demands and requirement (such as time windows), minimize traffic congestion and other negative environmental impact. The ultimate objective of this tool is to:

1. Maximize the utilization of commercial traffic servicing retailers and other business users in the downtown to increase the quality of city life.
2. Reduce the cost of vehicle ownership and transportation cost.
3. Maximize dynamic data exchange with control towers and other sensor networks.



Adapted from: OneMotoring[10]

Figure 8. Scheduling and Routing Efficiency

[9] J Barceló, H Grzybowska, and S Pardo, "Vehicle Routing and Scheduling Models, Simulation and City Logistics," in *Dynamic Fleet Management* (Springer, 2007).
[10] OneMotoring. http://www.onemotoring.com.sg/. Accessed on 24-Oct-2013 11:20:00.

An electronic marketplace or e-Marketplace mechanism encourages stakeholders with diverse interest to interact and share their business requirements

An E-MARKETPLACE for Trade-offs

An electronic marketplace or e-Marketplace mechanism encourages stakeholders with diverse interest to interact and share their business requirements. The purpose of the market mechanism is to negotiate fair terms allocate tasks, cost and benefit to all stakeholders to reduce negative externalities and gain maximum industry efficiency.

In general, there are two classes of problems existing in mechanism design: non-cooperative and cooperative problems. In a non-cooperative problem, such as an auction, stakeholders compete with each other to utilize some common resources. They directly interact with the owners of resources, not their opponents. The main purposes of the e-Marketplace are:

1. To enable multiple stakeholders to collaborate across a software platform to bid and negotiate on spare capacities, delivery jobs, timings of deliveries and load consolidation.
2. To promote and maintain fairness and transparency within the mechanisms such that it is a win-win situation for all stakeholders.

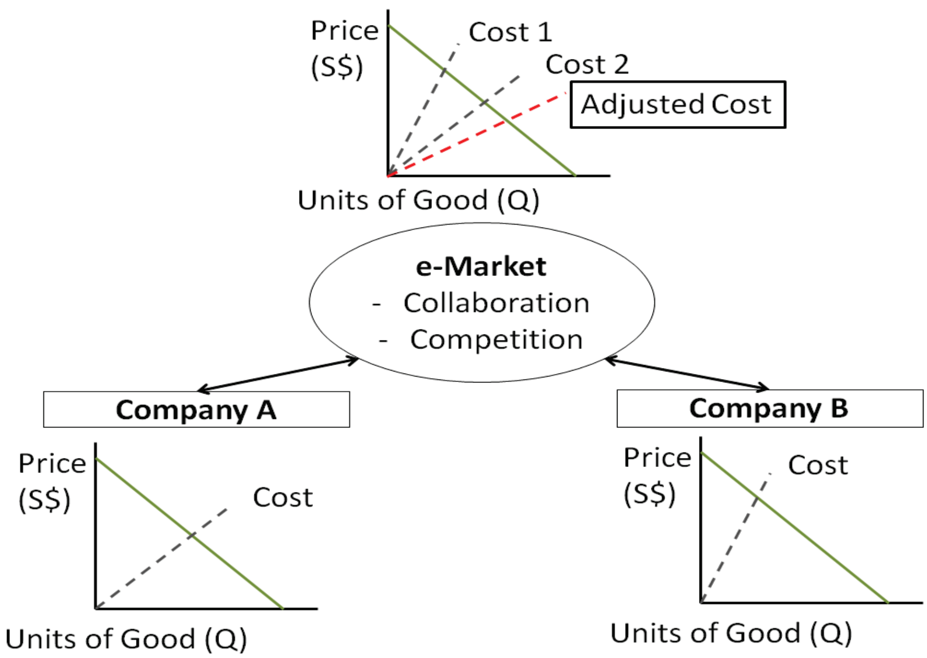


Figure 9. e-MarketPlace

INFORMATION VISIBILITY AND SHARING

We postulate that sharing of common information is important to promote collaboration. The key to synchronized logistics is information integration, harmonization and sharing through a common framework that comprehensively describes all the components in last-mile logistics and their relationships[11]. However, it is risky to share business intelligence as this may compromise competitive advantage. This implies the need for an IT platform to securely share information as needed and when needed.

The Singapore government through A*STAR has developed a data platform (A*DAX) designated for live access and integration of urban data, including logistics, which include public sector data as well as real-time data. A*DAX manages the data collected from different sources and provides security solutions for data collection. This shows A*DAX high potential as a platform and is extendable as a backbone to Singapore's last-mile logistics context.

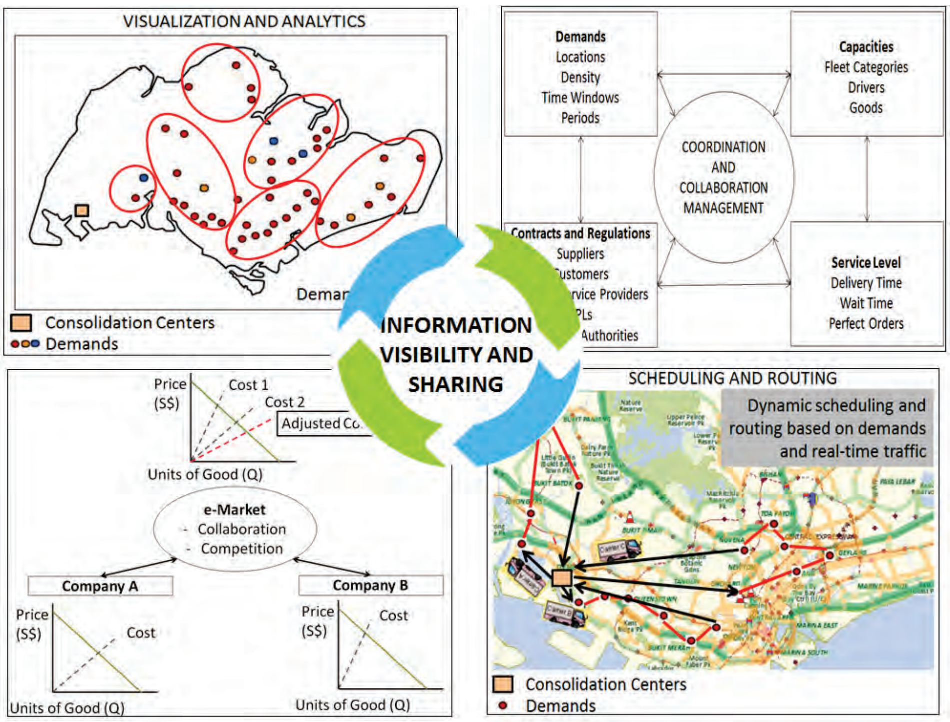


Figure 10. Information Visibility and Sharing

[11] H Chen, P J Daugherty, and T D Landry. Supply chain process integration: A theoretical framework. *Journal of Business Logistics* 30, no. 2: 27-46 (2009)

SUMMARY AND TAKEAWAYS

Last mile urban logistics is a little addressed but common logistics problem in the urban environment. It involves many stakeholders with different interest that often conflict.

Individual efficiency improvements of industry stakeholders to meet last-mile logistics challenges generally achieve these at the expense of others, which in the longer term cannot be sustainable. They can introduce several negative externalities such as increased congestion, reduction of travel speed and an increase of pollutants emitted – if sufficient in number, these initiatives result in a lose-lose situation.

The Synchronized Last Mile concept is based on collaboration across industries that will collectively improve efficiency and cost effectiveness by leveraging on the economies of scale. It will provide comprehensive analysis tools that encourage collaboration and at the same time tackle the business challenges of last-mile logistic. We have initiated a joint research collaboration to address these challenges and propose the Collaborative Urban Logistics initiatives that consist of 4 inter-related projects: (1) data harmonization & analytics, (2) synchronization & Multi-Objective Planning, (3) Eco-Friendly Collaborative Delivery and (4) Multi-Party Coordination.

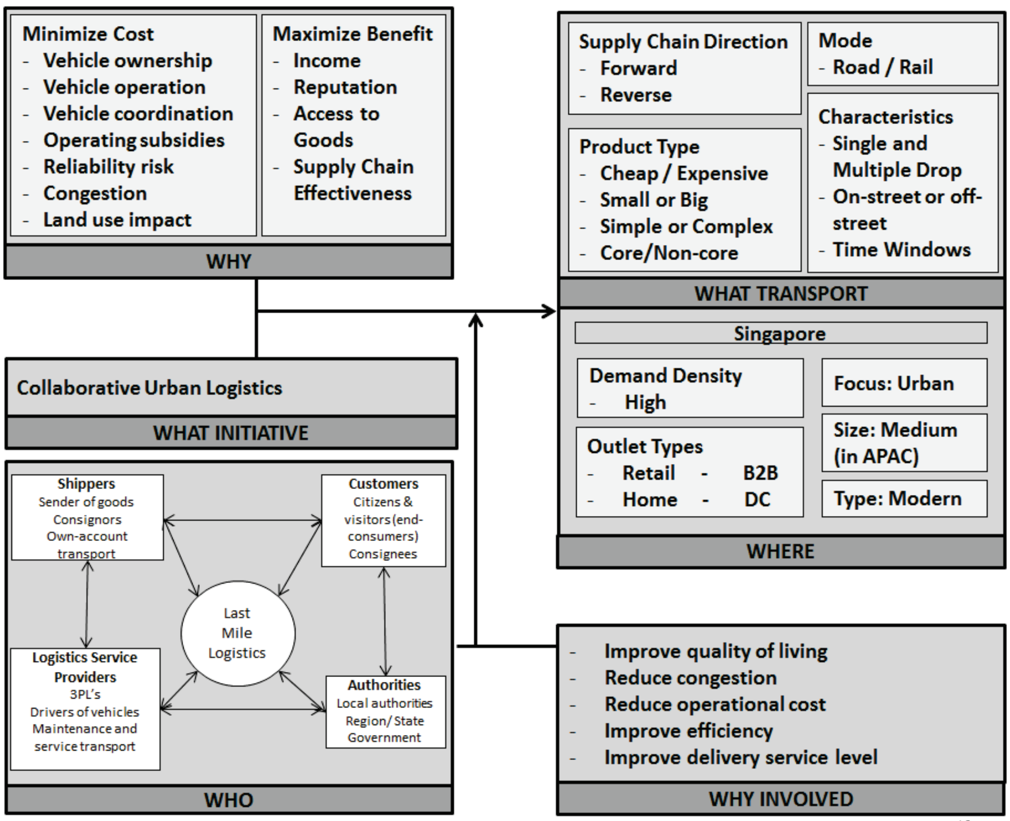


Figure 11. Collaborative Urban Logistics – Key Dimensions (adapted from Quak (2011)[12])

[12] H J Quak, "Urban Freight Transport: The Challenge of Sustainability," in *City Distribution and Urban Freight Transport: Multiple Perspectives*(Cheltenham, UK: Edward Elgar Publishing, 2011).

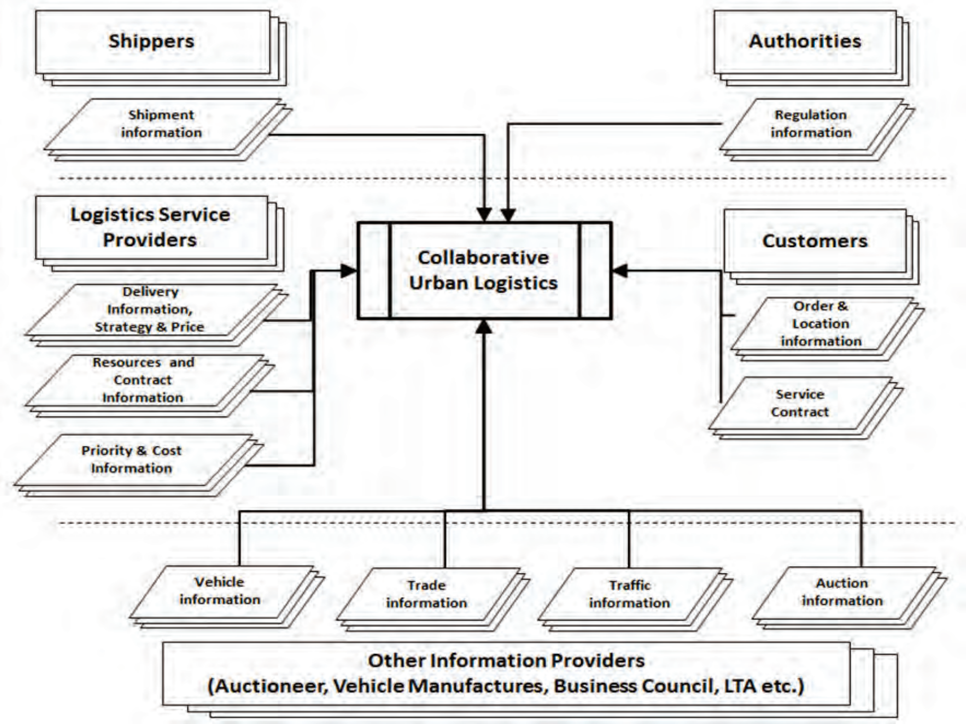


Figure 12. Stakeholder interaction

Our concept of Collaborative Urban Logistics encourages the clustering of customers, suppliers, and service providers to interact and collaborate in an equal and fair environment through an electronic marketplace. Using Singapore as a living laboratory for experimentation, these innovative concepts and paradigms may be translated into innovative business practices with selected pioneering companies.

We identified the key dimensions of the initiatives proposed using a methodology designed by Quak (2011)[13] as illustrated in Figure 11. This methodology identifies the basic dimensions for last-mile logistics initiatives and structures the last-mile logistics.

We also described the interaction between stakeholders as illustrated in Figure 12. In the Collaborative Urban Logistics, stakeholders from different industries, countries, may exchange data and information regarding factors affecting the delivery such as delivery locations, customer locations, customer demands, available resources, priority requirement, and cost changes; or their delivery strategies such as task scheduling and vehicle routing in real time as illustrated in Figure 12. We identified four main stakeholders: Shippers, LSPs, Customers, and Authorities. These stakeholders are directly interacting and sharing information in real time. Other than these four stakeholders, we identified other information providers that have indirect interests and interactions in last mile logistics.

Central to the Collaborative Urban Logistics concept is an electronic marketplace IT collaboration platform. Stakeholders can share sensitive information in this IT collaboration platform securely and anonymously to benefit all. The full details of all initiatives that will underpin this collaboration platform can be found in our 'Foundation Pillars for Effective Coordination of Urban Freight Movements' White Paper, available online.

[13] Ibid. page 9

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