Centre for Maritime Studies

CMS RESEARCH UPDATES

MARCH 2013

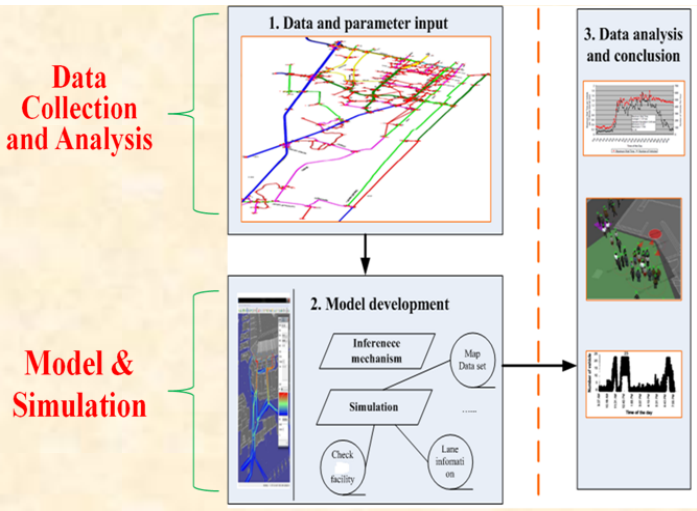
RESEARCH HIGHLIGHT 1: DEVELOPING A SIMULATION MODEL FOR BORDER CROSSING SYSTEM (TRACK LEADER: DR RAYMOND ONG; RESEARCHER: DR DU GANG)

CHALLENGE

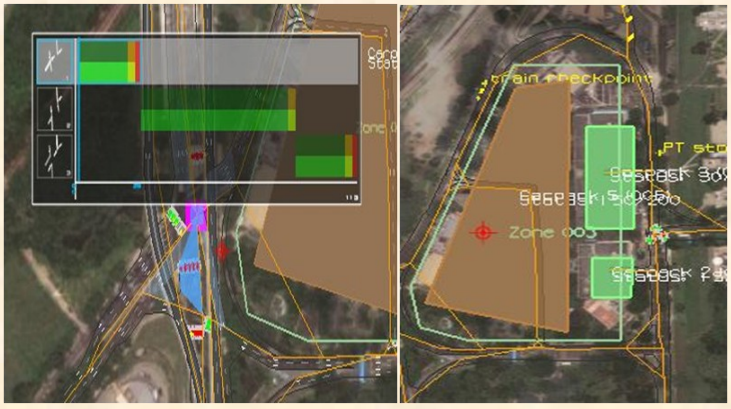
- Border crossings around the world face challenges in ensuring efficient and secure checkpoint operations, amidst increasing vehicular and passenger traffic.
- In order to ensure transportation safety and efficiency, this study looks into the development of a simulation model for a border crossing system that reflects the current-day throughput situation with detailed breakdown for each mode of vehicular transport (Car, Bus, Motorcycle, Lorry and Train) and its passengers at a border crossing.

METHODOLOGY

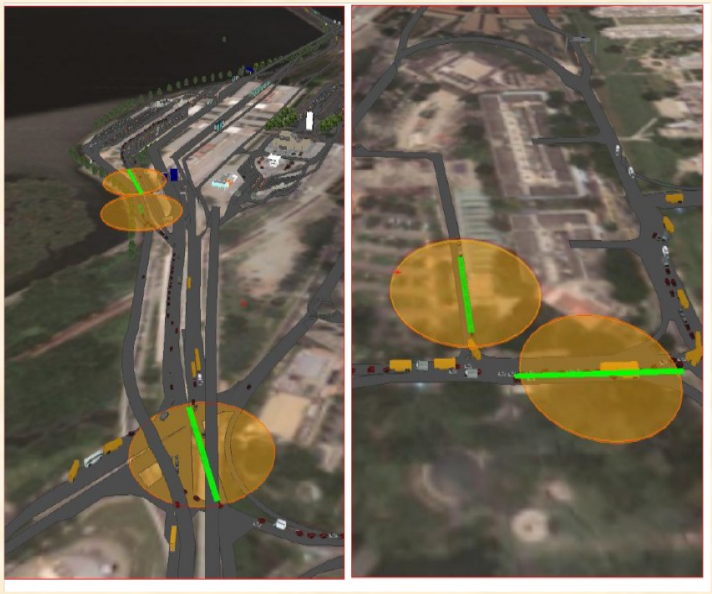
- With consultation from relevant authorities, the research collects relevant data throughput data of current-day operations for the different entry modes.
- Observation and collection of the Authority's average processing time for each mode of entry (e.g. average time taken to process one motorcycle/ heavy vehicle/ passenger car, bus passengers).
- With expertise in traffic operations modeling, a model shall be developed to simulate the throughput at border crossing and its vicinity.
- The model shall then be calibrated and validated against the collected current-day operations data, with detailed breakdown for each mode of vehicular transport for the super-peak, peak and normal scenarios.



MODEL DEVELOPMENT



RESULT ANALYSIS



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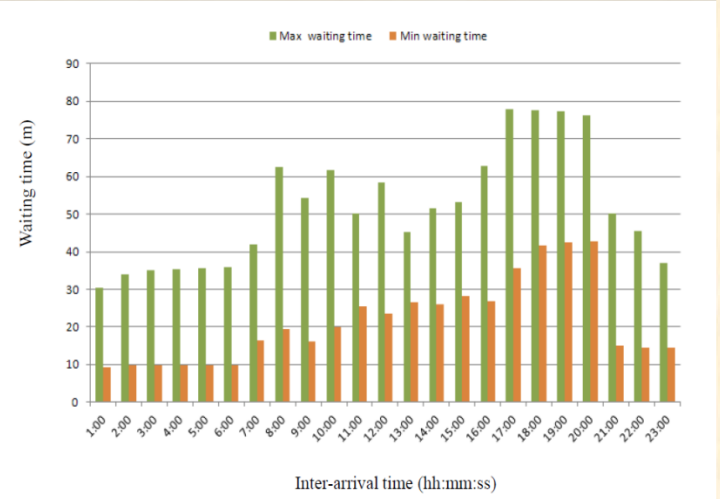
CONCLUSION & DISCUSSION

- Some factors affecting the simulation process have been identified
- Use of simulation to evaluate effect of demand on road congestion
- Such models can then be implemented to evaluate the effect of demand on facilities, roads, streets and parking facilities, as well as evaluate the pedestrian flow within the facility
- It can benefit border institutions in their decision-making and queuing performance evaluation for Border crossing systems

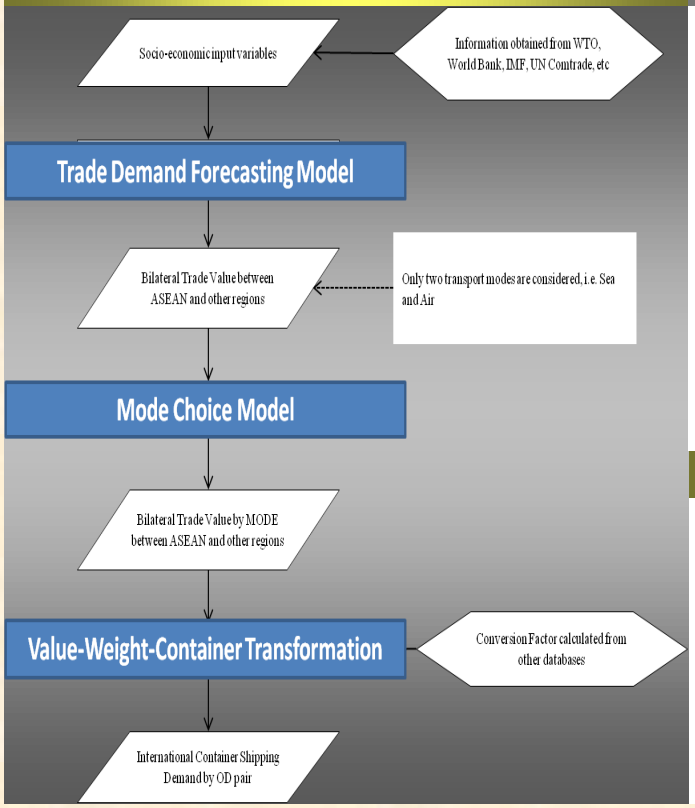


RESEARCH HIGHLIGHT 2: CONTAINER TRADE DEMAND FORECASTING USING ECONOMIC TRADE MODEL (TRACK LEADER: DR RAYMOND ONG; RESEARCHER: MS MAGGIE SOU WENG SUT)

CHALLENGES

The container trade demand forecasting aims to use the economic trade model to forecast future cargo trade demand. It includes bilateral trade flow between countries, freight mode choice model using available macroscopic trade data and also investigation in transfer function from monetary value to number of containers.

CONCEPTUAL FRAMEWORK



METHODOLOGY

- Since global trade is involved in this study, thus a detailed and comprehensive database and trade model has to be employed. In this trade model, a computable general equilibrium model, a widely applied in both academic and practical fields, is deployed here together with a global trade database.
- Due to lack of detailed shipment data from shipping company, only publicly available macroscopic trade data are only available for determining the transport mode in which a particular commodity is carried by at the strategic planner's data. Various discrete choice models are developed based on different trade routes.

SIGNIFICANCE & APPLICATIONS

- Demand trade forecasting is of particular practical importance to government and policy makers for making decisions on related trade policies or investment in infra-structure.
- It helps to fill in the missing linkage between the econo-mists and logistics experts as its fundamentals are a com-bination of trade demand derived from economic theories and modal split by applying transportation models.

PUBLISHED TECHNICAL PAPERS (WITH ABSTRACTS)

1. Shuaian Wang, Qiang Meng, and Michael G.H. Bell, (2013), Liner ship route capacity utilization estimation with a bounded polyhedral container shipment demand pattern, Transportation Research Part B: Methodological, Vol 47, 57-76.

Abstract:

This paper aims to estimate capacity utilization of a liner ship route with a bounded polyhedral container shipment demand pattern, arising in the liner container shipping industry. The proposed maximum and minimum liner ship route capacity utilization problems are formulated as a linear programming model and a min–max model, respectively. We examine two fundamental properties of the min–max model. These two nice properties enable us to develop two ε-optimal global optimization algorithms for solving the min–max model, which find a globally ε-optimal solution by iteratively cutting off the bounded polyhedral container shipment demand set with a cut. The latter algorithm overcomes non-convexity of the remaining feasible demand set generated by the former algorithm via a novel hyper plane cut. Each hyper plane cut can assure that the current vertex of the polyhedral demand set is cut off, whereas solutions that may improve the current one by more than a factor of ε are retained. Extensive numerical experiments for problems larger than those encountered in real applications demonstrate the computational efficacy of the latter algorithm.

2. Qiang Meng, Zhiyuan Liu & Shuaian Wang, (2013), Asymmetric stochastic user equilibrium problem with elastic demand and link capacity constraints, Transportmetrica A: Transport Science,

Abstract:

This paper focuses on model development and algorithm design for the general stochastic user equilibrium (SUE) problem with elastic demand, asymmetric link travel time functions and link capacity constraints. It first defines the generalised SUE conditions using generalised link travel time. An equivalent variational inequality (VI) model for these generalised SUE conditions is then developed and it is rigorously proven to be monotone and uniform Lipschitz-continuous. These two properties of the proposed VI model ensure the global convergence of the self-adaptive prediction–correction algorithm incorporating cost averaging method as a solution algorithm. Finally, a numerical example is utilised to assess the performance of the proposed VI model and solution algorithm.

3. Shuaian Wang, Qiang Meng, Zhuo Sun, (2013), Container routing in liner shipping, in Transportation Research Part E: Logistics and Transportation Review, 49:1, 1-7

Abstract:

Container paths play an important role in liner shipping services with container transshipment operations. In the literature, link-based multi-commodity flow formulations are widely used for container routing. However, they have two deficiencies: the level of service in terms of the origin-to-destination transit time is not incorporated and maritime cabotage may be violated. To overcome these deficiencies, we first present an operational network representation of a liner shipping network. Based on the network, an integer linear programming model is formulated to obtain container paths with minimum cost. Finally, we add constraints to the integer linear programming model, excluding those paths already obtained, so as to find all the container paths.

PUBLISHED TECHNICAL PAPERS (WITH ABSTRACTS)

4. Shuaian Wang, Qiang Meng, Zhiyuan Liu, (2013), A note on "Berth allocation considering fuel consumption and vessel emissions", Transportation Research Part E: Logistics and Transportation Review, 49:1, 49-54

Abstract:

Du et al. [Du, Y., Chen, Q., Quan, X., Long, L., Fung, R.Y.K., 2011. Berth allocation considering fuel consumption and vessel emissions. Transportation Research Part E 47, 1021–1037] dealt with a berth allocation problem incorporating ship' fuel consumption minimization. To address the difficulty posed by the power function between fuel consumption rate and sailing speed, they formulated a tractable mixed-integer second-order cone programming model. We propose two quadratic outer approximation approaches that can handle general fuel consumption rate functions more efficiently. In the static quadratic outer approximation approach, the approximation lines are generated a priori. In the dynamic quadratic outer approximation approach, the approximation lines are generated dynamically. Numerical experiments demonstrate the advantages of the two approaches.

5. Wang, S and Q Meng, (2013), Reversing port rotation directions in a container liner shipping network, Transportation Research Part B-Methodological, Vol 50, 61-73

Abstract:

Reversing port rotation directions of ship routes is a practical alteration of container liner shipping networks. The port rotation directions of ship routes not only affect the transit time of containers, as has been recognized by the literature, but also the shipping capacity and transshipment cost. This paper aims to obtain the optimal port rotation directions that minimize the generalized network-wide cost including transshipment cost, slot-purchasing cost and inventory cost. A mixed-integer linear programming model is proposed for the optimal port rotation direction optimization problem and it nests a minimum cost multi-commodity network flow model. The proposed model is applied to a liner shipping network operated by a global liner shipping company. Results demonstrate that real-case instances could be efficiently solved and significant cost reductions are gained by optimization of port rotation directions.

6. Xiaomin Sheng, Loo Hay Lee and Ek Peng Chew, (2013), Dynamic determination of vessel speed and selection of bunkering ports for liner shipping under stochastic environment, OR Spectrum.

Abstract:

In this work, we study a liner shipping operational problem which considers how to dynamically determine the vessel speed and refueling decisions, for a single vessel in one service route. Our model is a multi-stage dynamic model, where the stochastic nature of the bunker prices is represented by a scenario tree structure. Also, we explicitly incorporate the uncertainty of bunker consumption rates into our model. As the model is a large-scale mixed integer programming model, we adopt a modified rolling horizon method to tackle the problem. Numerical results show that our framework provides a lower overall cost and more reliable schedule compared with the stationary model of a related work.

CONFERENCE PAPERS (WITH ABSTRACTS)

1. Wang, Shuaian, Liu, Zhiyuan, Meng, Qiang, (2013), Systematic Network Design for Liner Shipping Services. In: *92nd Annual Meeting of the Transportation Research Board*, Washington DC, 13-17 January.

Abstract:

This paper addresses a systematic design of liner shipping network. Many practical features in real-world operations are considered, which include multi-type containers, container transshipment operations, empty container repositioning, origin-to-destination transit time constraint, consistent services with the current network, and joint services with other liner shipping companies. Given a set of candidate ship routes, some of these routes must be used while the others are optional for use. Hence, a mixed-integer linear programming model is first proposed for the selection of the optional ship routes. Solving this model also gives the laden and empty container flow on the selected ship routes. Based on the results of this model, some techniques are proposed to refine the ship routes, by changing existing ship routes, designing new ship routes, and removing some ship routes. Finally, a large scale numerical test is performed, based on the global shipping network of a liner shipping company, consisting of 166 ports.

2. Miao, Lixin, Meng, Qiang, Ruan, Qingfang, (2013), Vehicle Routing Problem with Pickups, Deliveries, and Handling Costs. In: *92nd Annual Meeting of the Transportation Research Board*, Washington DC, 13-17 January.

Abstract:

This paper proposes a novel and practical vehicle routing problem with pickups, deliveries and handling costs (VRPPD-H). The VRPPD-H extends the conventional vehicle routing problem with pickups and deliveries (VRPPD) by taking into account additional handling costs caused by loading and unloading operations for cargo rearrangement. Four mixed integer linear programming models are first built for the VRPPD-H under the four different cargo storage and handling policies. Two types of branch-and-cut exact algorithms are subsequently used to solve each of these four models. Finally, numerical experiments are carried out to assess the models and algorithms proposed in this study.

3. Ticy Veluvellel Thomas, (2013), The Legal Regime of Maritime Piracy: Problems and Progresses. In: *The Legal Experts Meeting to commemorate the 30th Anniversary of the United Nations Conventions on the Law of the Sea (UNCLOS),* New Delhi, 5 March.

Abstract:

As a speaker in the Session dealing with Maritime Security and Piracy, my presentation titled "The Legal Regime of Maritime Piracy: Problems and Progresses" provided an overview of the maritime piracy regime, examined the evolving developments in the regime and evaluated the progresses. The presentation elicited positive response for its singular research quality and comprehensiveness and stimulated interesting discussion from the floor in the light of the ongoing Enrica Lexie case.

CMS RESEARCH SEMINARS

1. Major Ports in East Asia and Southeast Asia, by Researcher Ms Yang Lingxiao (Track Leader: Prof Fwa)

Seminar Abstract:

The regions of East and Southeast Asia now enjoy the strongest economic and trade growth in the world, serving as a major centre of gravity of global sea-freight activities. In light of these trends, ports in these regions are receiving increasing attention. This project aims to make available in one platform the updated key infrastructural and operational data of major ports in these two regions. Firstly the presentation will provide a brief introduction of the project. Then, several examples of preliminary data analysis of the database will be presented, to show the facility property or efficiency of a terminal or port. Finally, the seminar will discuss briefly how users can access the database to view the data of these ports.

2. Hub-and-Spoke Intermodal Network for Freight Transport in the Philippines, by Visiting Researcher Ms Anita II Alvarez Odchimar (Track Leader: A/Prof Meng Qiang)

Seminar Abstract:

The PhD research generally aims to compare two types of domestic cargo flow in the archipelagic Philippines: hub-and-spoke and point-to-point. The hub-and-spoke network considers intermodal transport – the use of truck and roll -on roll-off vessels for the spoke links, and container vessel for the hub-to-hub links. This network is being designed by modeling a hub location problem with multiple allocation of flows, capacitated hub ports, variable discounts offered in the hub-to-hub links, and travel time constraints; employing Lagrangian relaxation to solve the problem. The hub-and-spoke and point-to-point networks will be evaluated by cost and service (travel time) criteria.

3. Publishing trajectories with differential privacy guarantees, by Researcher Dr Jiang Kaifeng (Track Leader: A/Prof Stephane Bressan)

Seminar Abstract:

The pervasiveness of location-acquisition technologies has made it possible to collect the movement data of individuals or vehicles. However, it has to be carefully managed to ensure that there is no privacy breach. In this paper, we investigate the problem of publishing trajectory data under the differential privacy model. A straightforward solution is to add noise to a trajectory - this can be done either by adding noise to each coordinate of the position, to each position of the trajectory, or to the whole trajectory. However, such naive approaches result in trajectories with zigzag shapes and many crossings, making the published trajectories of little practical use. We introduce a mechanism called SDD (Sampling Distance and Direction), which is ε-differentially private. SDD samples a suitable direction and distance at each position to publish the next possible position. Numerical experiments conducted on real ship trajectories demonstrate that our proposed mechanism can deliver ship trajectories that are of good practical utility.

4. Stowaways, by Researcher Ms Remani Chinchu Balaji (Track Leader: Prof Bernard Tan)

Seminar Abstract:

A stowaway is generally understood to be a person who secretly boards a vehicle (an aircraft, ship, cargo truck or train) to travel without paying and without being detected. These stowaways cause considerable difficulties for people and authorities that discover their presence both during the travel or upon arrival of these persons at a destination. This seminar is an attempt to explore the problems that are caused by stowaways in the maritime industry. The paper will seek to identify the problems, the parties involved, various steps that can be taken to prevent stowaway incidents and the legal and policy framework that is in place to address the stowaway problems.

CMS RESEARCH SEMINARS

5. Stochastic Congestion Pricing among Multiple Regions: Competition and Cooperation, by Researcher Dr Wang Hua (Track Leader: A/Prof Meng Qiang)

Seminar Abstract:

Previous studies of road congestion pricing problem assume that transportation networks are managed by a central administrative authority with an objective of improving the performance of the whole network. In practice, a transportation network may comprise of multiple independent local regions with relatively independent objectives. In this paper, we investigate the cooperative and competitive behaviors among multiple regions in congestion pricing considering stochastic conditions, especially demand uncertainty is taken into account in transportation modeling. Demand uncertainty refers to the fluctuations of day-to-day total number of vehicular trip. The corresponding congestion pricing models are formulated as bi-level programs. In the upper level, congestion pricing model either aims to maximize the regional social welfare in competitive schemes or attempts to maximize the total social welfare of multiple regions in cooperative schemes. In the lower level, network travelers are assumed to follow a reliability-based stochastic user equilibrium principle considering risks of arriving late or early under uncertain conditions. Such equilibrium traffic assignment is formulated as a fixed point problem and incorporated into the pricing model as an inherent constraint. A heuristic solution algorithm on the basis of penalty method is proposed to solve the pricing models. Numerical examples are carried out to compare the effects of different pricing schemes and to analyze the impact of travel time reliability. It is found that cooperative pricing strategy performs better than competitive strategy in improving network performance, and the pricing effects of both schemes are quite sensitive to travel time reliability.

6. Key Technologies and Model Development for Checkpoint System, by Researcher Dr Du Gang (Track Leader: Dr Raymond Ong)

Seminar Abstract

The border administration institutions recognizes the impending challenges faced in ensuring efficient and secure checkpoint operations with increasing capacity of vehicular traffic and passenger across the checkpoint day and night. The reasonable and effective model and analysis for the checkpoint system with different traffic modes (such as motorcycle / heavy vehicle / car, bus, passengers so on) are crucial. In this study, some key technologies are discussed for checkpoint efficiency and security. A simulation model is developed for a checkpoint system. Some factors affecting the simulation process will be identified. This research will benefit hopefully border institutions for decision-making and queuing performance evaluation for the checkpoint system.

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