Centre for Maritime Studies

CMS RESEARCH UPDATES

NOVEMBER 2013

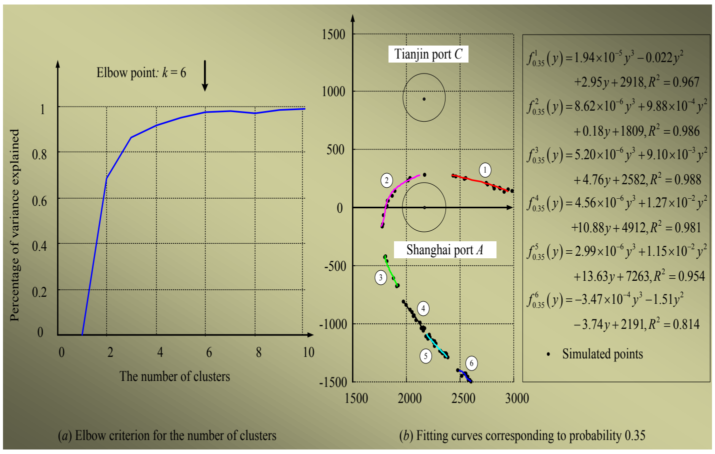
RESEARCH ACCOLADES

WCTR SOCIETY PRIZE FOR THE BEST CONFERENCE PAPER

Assoc. Prof Meng Qiang, a research track leader at CMS, is the leading member of a research team that was awarded the top prize for the Best Conference Paper, by the World Conference on Transportation Research (WCTR), at the 13th triennial WCTR held in Rio de Janeiro, Brazil on 15-18 July 2013.

The details of the Conference Paper are as follows:

Boundary Estimation of Probabilistic Port Hinterland for Intermodal Freight Transportation Operation, by A/Prof Meng Qiang, Prof Lixin Miao (of Tsinghua University) and Dr Wang Xinchang.



About the WCTR Society

The WCTR Society is an organisation whose purpose is to provide a forum for the interchange of ideas among transportation researchers, managers, policy makers, and educators from all over the world, from a perspective which is multi-modal, multi-disciplinary, and multi-sectoral. The Society has become a primary forum for such international exchanges in transportation. Its World Conferences are the place where leading transportation professionals from all countries convene to learn from one another.

IAME Best Paper Award

Assoc. Prof Anthony Chin, CMS research track leader, together with Dr Raymond Ong and Dr Yang Dong, have clinched the **Hanjin Prize** for Best Paper, awarded by the International Association of Maritime Economists (IAME), at the IAME Conference in Taipei, 6-8 September 2012.

The paper explores the use of trade data in mode choice analyses and how it can be effectively utilised to aid economists and transportation planners in formulating effective maritime freight strategies.

About the IAME and the Hanjin Prize

IAME provides a unique global conference for academics, key industry practitioners, and policy makers from diverse backgrounds and interests to meet, discuss and debate critical and challenging issues that will affect the future direction of international shipping, port and logistics research and practice.

The Hanjin Prize was established in 1998 by Hanjin Shipping and IAME with the aim of supporting scholars and academic development of shipping and logistics. The prize is awarded to the best paper at the IAME every year.

Centre for Maritime Studies

CMS RESEARCH UPDATES

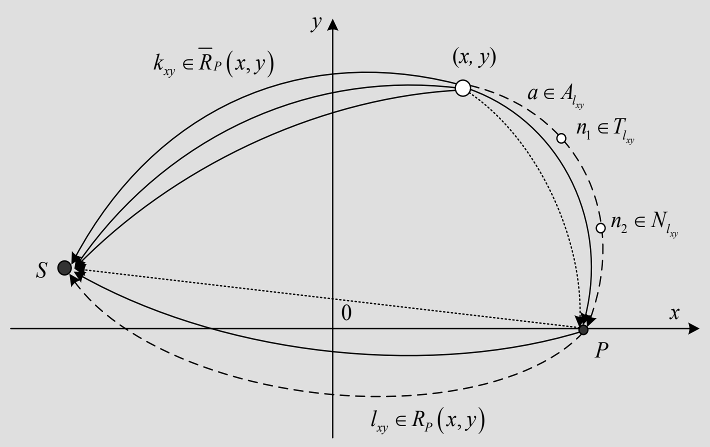
NOVEMBER 2013

RESEARCH HIGHLIGHT 1: BOUNDARY ESTIMATION OF PROBABILISTIC PORT HINTERLAND FOR INTERMODAL FREIGHT TRANSPORTATION OPERATION, BY A/PROF MENG QIANG, PROF LIXIN MIAO AND DR WANG XINCHANG. (AWARDED WCTR PRIZE FOR BEST PAPER)

PROBLEM STATEMENT

Consider port *P* and a specific destination *S*. To represent the port hinterland boundaries, we use an *x*-*y* plane coordinate system as shown in the figure below, where *P* is located on the *x*-axis. Given a point (*x*, *y*) as an origin surrounding *P*, the shippers around (*x*, *y*) intend to transport containers from (*x*, *y*) to *S* through available intermodal routes. Let *R*(*x*, *y*) be the set of all these available routes. *R*(*x*, *y*) can be classified into two exclusive subsets, $R_P(x,y)$ and $\bar{R}_P(x,y)$, where $R_P(x,y)$ consists of the routes traversing *P* and $\bar{R}_P(x,y)$ is the complement of $R_P(x,y)$ relative to *R*(*x*, *y*). It thus follows that $R(x,y)=R_P(x,y)\cup\bar{R}_P(x,y)$.

PORT HINTERLAND BOUNDARIES



Denoted by an intermodal route. It may consist of a sequence of nodes (i.e., points) as well as the links between two consecutive nodes in the x-y plane. A node can either represent a transfer node where containers are switched between different modes or a location where the handling of containers does not happen. The latter is referred to as regular node. One example regular node is the interaction of two roadways. Let $T_{l_{xy}}$ and $N_{l_{xy}}$ be the sets of all transfer and regular nodes on route l_{xy}, respectively.

MODEL DEVELOPMENT

According to the behavior assumption, shippers around (x,y) will choose the route with the minimum disutility from $R(x,y)$ to transport containers from (x,y) to *S*. According to the discrete choice theory (Ben-Akiva and Lerman 1985), the probability of shippers choosing port *P* is given by,

$$F(x,y)=\sum_{l_{xy}\in R_P(x,y)}\Pr\left[U_{l_{xy}}\le\min\left(U_{k_{xy}},k_{xy}\in R(x,y),k_{xy}\ne l_{xy}\right)\right]$$

where $R_P(x,y)$ is the set of routes that traverses through P. Since $\mathbf{U}_{xy}$ is a Gaussian random vector, the probability of shippers selecting route $l_{xy}\in R_P(x,y)$ can be computed by,

$$\Pr\left[U_{l_{xy}}\le\min_{\substack{k_{xy}\in R(x,y)\\ k_{xy}\ne l_{xy}}}\left(U_{k_{xy}}\right)\right]=\int_{u_{l_{xy}}<u_{1_{xy}}}\cdots\int_{u_{l_{xy}}=-\infty}^{u_{l_{xy}}=\infty}\cdots\int_{u_{l_{xy}}<u_{I_{xy}}}\left[(2\pi)^{I_{xy}}\left|\Sigma_{xy}\right|\right]^{-0.5}\cdot \exp\left\{-\frac{1}{2}\left(\mathbf{u}_{xy}-\mathbf{V}_{xy}\right)'\left(\Sigma_{xy}\right)^{-1}\left(\mathbf{u}_{xy}-\mathbf{V}_{xy}\right)\right\}du_{1_{xy}}\,du_{2_{xy}}\ldots du_{I_{xy}}$$

RESEARCH HIGHLIGHT 1: BOUNDARY ESTIMATION OF PROBABILISTIC PORT HINTERLAND FOR INTERMODAL FREIGHT TRANSPORTATION OPERATION, BY A/PROF MENG QIANG, PROF LIXIN MIAO AND DR WANG XINCHANG.

THE MONTE CARLO SAMPLING ALGORITHM

Step 1 (Discretization) Discretize area Ω by generating horizontal and vertical lines with regular space Δy between two consecutive horizontal lines and regular space Δx between two successive vertical lines. Let $\bar{\Omega}$ denote the set of all the points intersected by these horizontal lines and vertical lines.

Step 2 (Monte Carlo simulation) For each point (*x*, *y*) intersected by a horizontal line and a vertical line, i.e. $(x,y)\in\bar{\Omega}$, perform the following operations:

Let $\Gamma(x,y)$ be the set of these samples, namely,

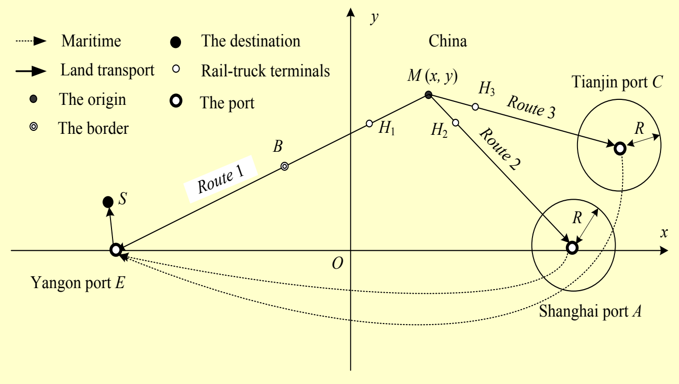
$$\Gamma(x,y)=\left\{\left(u_{1_{xy}}^{(i)},u_{2_{xy}}^{(i)},\cdots,u_{l_{xy}}^{(i)}\right)\middle| i=1,2,\cdots,N\right\}$$

(Probability estimation) Estimate the probability $F(x,y)$ by estimator,

$$\hat{F}(x,y)=\sum_{l_{xy}\in R_P(x,y)}\frac{K_{l_{xy}}}{N}$$

$K_{l_{xy}}$ is the number of the vectors (samples) in set $\Gamma(x,y)$, in each of which the observation representing the transportation disutility of route l_{xy} is the minimum among all the routes in *R*(x,y). $K_{l_{xy}}$ is the cardinality of the following subset of set

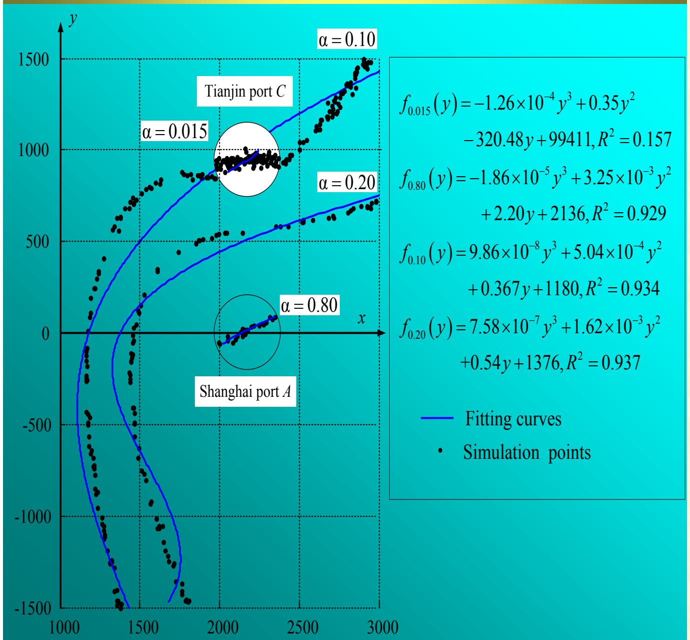
$$\Theta(l_{xy})=\left\{\left(u_{1_{xy}},u_{2_{xy}},\cdots,u_{l_{xy}}\right)\in\Gamma(x,y)\middle| u_{l_{xy}}\le u_{k_{xy}},k_{xy}\in R(x,y),k_{xy}\ne l_{xy}\right\}$$



ILLUSTRATIVE EXAMPLE

The illustrated example above demonstrates the proposed approach. The diagram shows the intermodal network involving three intermodal routes. We aim to estimate the boundaries of the hinterland of Shanghai port by considering China and Mainland Southeast Asia (CMSA) as study area and a point in Myanmar as destination S.

HINTERLAND BOUNDARY CURVES



CONCLUSIONS

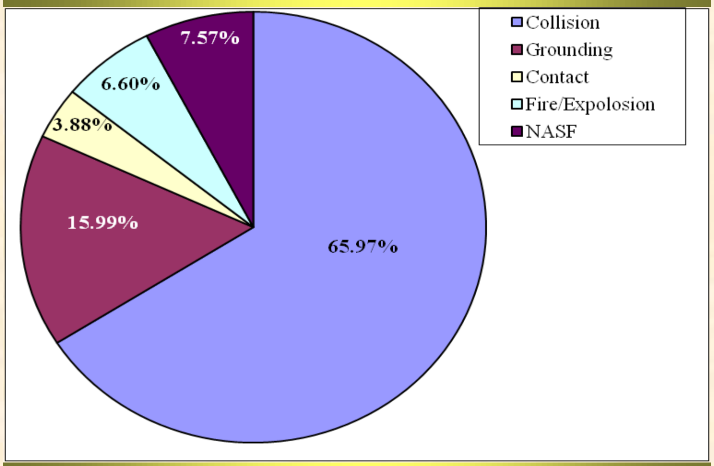
This paper proposes a new definition of probabilistic port hinterland for intermodal freight transportation operation systems. We developed mathematical expressions of the probabilistic hinterland of a specific port and its boundaries with respect to certain probabilities. To graphically determine the hinterland boundaries, a Monte Carlo sampling algorithm, which integrates a cluster analysis method and boundary curve fitting method, was proposed. Moreover, we derived a lower bound on the sample size that is needed in the simulation algorithm in order to achieve a certain level of significance. An illustrative example was finally provided to demonstrate the applicability of the proposed model and algorithm.

RESEARCH HIGHLIGHT 2: STUDY ON NAVIGATION SAFETY ASSESSMENT OF THE MALACCA AND SINGAPORE STRAITS, BY A/PROF MENG QIANG (NUS), COLLABORATIVE PARTNER DALIAN MARITIME UNIVERSITY.

DATA COLLECTION & ANALYSIS

- Purchased one-month (July of 2009) real time AIS records of ship movements in the Straits of Malacca and Singapore from the Lloyd's List Intelligence Ltd
- About 4 million AIS records have been analyzed for the July of 2009
- Each AIS record includes: Time, category of report, IMO number, vessel name, MMSI number, latitude, longitude, speed over ground, and heading over ground

QRA MODEL VALIDATION



PARAMETERS IN QRA SOFTWARE

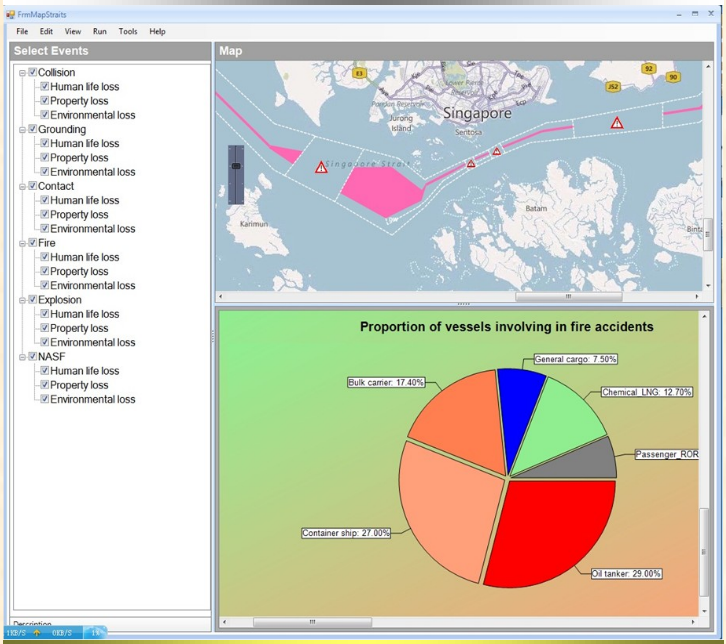
Input Parameters

- AIS data
- Event tree parameters
- Consequence parameters

Output Parameters

- Frequency
- Consequence
- Relationship between frequency and consequence
- Distribution of vessels involving in an accident

Quantitative Risk Assessment SOFTWARE



RESEARCH METHODOLOGY

- Build new models to estimate the occurrence frequency of an accident
- Build event trees to estimate the possible consequence of an accident
- Object-oriented programming approach

MODEL VALIDATION

- Comparing the occurrence frequency from the QRA software and the historical data from the IMO'GISIS database
- One month's (July 2009) AIS data from the Lloyd's MIU AIS database are imported into the QRA model
- Comparison results show that the proposed QRA model is able to accurately estimate accident occurrence frequency in the Singapore Strait

Selected Publications

[1] Qu X. B., Meng Q. and Li, S. Y. (2011). Ship collision risk assessment for the Singapore Strait. Accident Analysis and Prevention 43, pp.2030-2036.

[2] Weng, J., Meng, Q., Qu, X., (2012). Vessel collision frequency estimation in the Singapore Strait. Journal of Navigation, 65(2), pp.207-221.

[3] Li, S. Y, Meng, Q. and Qu, X. B. (2011). Overview of maritime waterway quantitative risk assessment models, Risk Analysis, 32(3), pp.496-512.

[4] Qu, X. B. and Meng, Q. (2012). The Economic Importance of the Straits of Malacca and Singapore: An Extreme-Scenario Analysis. Transportation Research Part E 48, pp.258-265 .

PUBLISHED TECHNICAL PAPERS (WITH ABSTRACTS)

1. Zhuo SUN, Kok Choon TAN, Loo Hay LEE and Ek Peng CHEW, (2013), Design and Evaluation of Mega Container Terminal Configurations: An Integrated Simulation Framework. *Simulation: Transactions of the Society for Modeling and Simulation International*

Abstract:

Operators of busy container terminals need to periodically evaluate options for capacity expansion in order to meet the increasing demands for container handling at their terminals. When planning such capital intensive investments, it is important to find an efficient and effective way to design and evaluate various possible terminal layout and equipment configurations. The issue is further complicated for mega -sized container terminals which consist of multiple berths and yards due to pre-existing geological conditions. This paper proposes an integrated simulation framework to facilitate the design and evaluation of mega container terminal configurations with integrated multiple berths and yards. There are two major components in this framework: a geographical information system (GIS) and a multi-agent system (MAS). The former is used to design specific terminal configurations which can be then simulated and evaluated by the latter. An application of the framework to a real container terminal expansion problem demonstrates the validity of the framework. Results obtained from simulation models generated efficiently by the framework are used to help terminal planners make reasonable decisions.

2. Hongtao Hu, Youfang Huang, Lu Zhen, Byung Kwon Lee, Loo Hay Lee, Ek Peng Chew, (2013), A decomposition method to analyze the performance of frame bridge based automated container terminal. *Expert Systems with Applications*, 41:2, 357-365.

Abstract:

This paper studies a new automated container terminal (ACT) system which utilizes multi-storey frame bridges and rail-mounted trolleys to transport containers between the quay and the yard. Different from widely used AGV–ACT systems, the ACT system studied in this paper uses three types of handling machines, which collaborate to transport containers. This study decomposes the container flow in the new ACT system into three queuing sub-networks. Then an iterative method is developed to analyze the operational efficiency of the ACT system. We analyze its transport efficiency by comparing with the widely used AGV-based systems. This study tries to help port operators better understand the relative merits of this new design and decide whether it is applicable in their terminals.

3. Hongtao Hu, Byung Kwon Lee, Youfang Huang, Loo Hay Lee, and Ek Peng Chew, (2013), Performance Analysis on Transfer Platforms in Frame Bridge Based Automated Container Terminals. *Mathematical Problems in Engineering*, Volume 2013 (2013), Article ID 593847, 8 pages.

Abstract:

This paper studies a new automated container terminal (ACT) system which utilizes multistory frame bridges and rail-mounted trolleys to transport containers between the quay and the yard. Beside typical ACT systems use trucks or automated guided vehicles for transporting containers between quay cranes and yard cranes, the new design uses three types of handling machines, namely, ground trolleys (GTs), transfer platforms (TPs), and frame trolleys (FTs). These three types of handling machines collaborate with one another to transport containers. This study decomposes the system into several subsystems. Each subsystem has one TP and several FTs and GTs dedicated to this TP. Then, a Markov chain model is developed to analyze the throughput of TPs. At last, the performance of the new ACT system is estimated. Sensitivity analyzes the numbers, and the processing rates of trolleys are conducted through the numeric experiments.

PUBLISHED TECHNICAL PAPERS (WITH ABSTRACTS)

4. Kaifeng Jiang, Dongxu Shao, Stéphane Bressan, Thomas Kister, and Kian-Lee Tan, (2013), "Publishing trajectories with differential privacy guarantees". ***Proceedings of The 25th International Conference on Scientific and Statistical Database Management (SSDBM)*** **2013, Baltimore, Maryland, United States, July.**

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.

CONFERENCE PAPERS (WITH ABSTRACTS)

1. Sou, W. S., Ong, G. P. and Chin, A. T. H., (2013), An Exploratory Study to Forecast Container Demand Using Economic Trade Models: A Case Study of the ASEAN Region. ***Proceedings of the 2013 International Association of Maritime Economists (IAME) Conference*****, 3-5 July 2013, Marseille, France.**

Abstract:

Maritime container demand forecasting in the context of international trade is of particular concern to government and policy makers. Numerous efforts have been made in past research to forecast container demand but most of these studies either adopt an economic approach or a transportation perspective. Few studies actually consider the forecasting of maritime container demand from an integrative economic trade-transportation modelling perspective. This paper presents the development of a quantitative demand forecasting approach to predict future seaborne container demand in the ASEAN (Association of Southeast Asian Nations) region (consisting of Singapore, Malaysia, Indonesia, Brunei, Thailand, Philippines, Vietnam, Laos, Cambodia and Myanmar), and between the region and its major trading partners (such as EU-27, USA and China). Computable general equilibrium models were first developed to derive the amount of trade flow between countries. A scientific approach is then proposed to estimate the amount of seaborne trade between countries. Trade volumes within the ASEAN region and between ASEAN and its trading partners are predicted using the model and subsequent maritime trade forecast between the regions and its trading partners are predicted and analysed. This study shows that Singapore is expected to maintain its importance in the maritime shipping and Malaysia is expected to be more competitive within the ASEAN region.

CONFERENCE PAPERS (WITH ABSTRACTS)

1. Byung Kwon Lee, Loo Hay Lee, Ek Peng Chew, (2013), Analysis of Throughput Variability on Container Port Scalability. *The International Conference on Logistics and Maritime Systems*, Singapore, 12-14 September.

Abstract:

Shipping liners run various sizes of vessels including mega container vessels and container ports need to provide the high productivity represented by the throughput capacity to meet the required throughput demand as well as the storage space requirement. A container port typically needs to improve its scalability such as expanding the land scale, enlarging the number of resources, applying the advanced handling techniques, and other operational activities to improve the handling performance. This study aims to discuss the effect of the port scalability parameters on the throughput requirement estimated from vessel arrivals consisted of different types of vessels. The handling variability created by the effects is analyzed through the sensitivity analyzes in terms of the operational efficiency in both the quay and the yard. The results would be used to control the vessel arrivals leading to the throughput requirement.

2. Meng Qiang, Lixin Miao and Wang Xinchang, (2013), Boundary Estimation of Probabilistic Port Hinterland for Intermodal Freight Transportation Operation. *The 13th Triennial WCTR, World Conference on Transportation Research*, Rio de Janeiro, Brazil, 15-18 July 2013 – Awarded WCTR Society Prize for the Best Paper of the Conference.

Abstract:

This paper estimates the probabilistic port hinterland for intermodal freight transportation. We first give a definition of the probabilistic hinterland of a port. By assuming that the disutilities of all intermodal routes are Gaussian distributed, a mathematical model is then developed to represent the port hinterland. A Monte Carlo sampling algorithm is proposed to graphically determine the probabilistic port hinterland boundaries. A numerical example is finally provided to demonstrate our approach.

3. Kaifeng Jiang, Dongxu Shao, Thomas Kister, Kian-Lee Tan, Stéphane Bressan, Weidong Chen, (2013), Publishing bunker fuel consumption with differential privacy guarantees. *The International Conference on Logistics and Maritime Systems*, Singapore, 12-14 Sept.

Abstract:

In this paper we propose two methods for publishing bunker fuel consumption of the ship while preserving the differential privacy. The widely used Laplace mechanism achieves the differential privacy by adding independent and identically distributed Laplace noise to each component of the true answers to queries. The first method, named input perturbation mechanism, is to add Laplace noise to the ship's speed and use the perturbed ship speed for publishing bunker fuel consumption. The second method, named output perturbation mechanism, is to add Laplace noise to the true bunker fuel consumption of the ship to achieve the differential privacy. We are able to show that the utility of the output perturbation mechanism is generally better than the utility of the input perturbation mechanism.

CMS RESEARCH SEMINARS

1. Relationship between Commodity Trade Value, Weight and Container – An Overview, by Researcher Ms Maggie Sou (Track Leader: Dr Raymond Ong)

Seminar Abstract:

This seminar aims to present a preliminary study on the relationship between commodity trade value, trade weight and, in particular, amount of container flow. In most cases, maritime freight demand forecasting are either measured in terms of traded value or amount of container flow. However, only limited investigation in the relationship between the these measurements exist, especially in the conversion among these values. Hence, one may not be able to interpret the estimated maritime commodity traded value to traded weight or number of TEU, and vice versa. Thus, a case study about the relationship between these values in the U.S. maritime trade is illustrated.

2. Analysis of Shipping Alliance for a Long-Haul Route, Dr Xu Zui (Track Leader: A/Prof Meng Qiang)

Seminar Abstract:

Shipping alliance is very popular in the recent years. Some carriers form an alliance by using bigger container ships and sharing the capacity of each other's ships, aiming to increase the capacity utilization rate, therefore reduce the operational cost and improve the service frequency. Firstly, we analyze the characteristics in shipping alliance. Secondly, we build a model to formulate the alliance's problems. Thirdly, we put forward a mechanism to verify whether the alliance can be achieved. Finally, we demonstrate the mechanism by using numerical experiments.

3. Sydney Coordinated Adaptive Traffic System - A Review, by Researcher Ms Lakshmi Rajasekhar (Track Leader: Dr Raymond Ong)

Seminar Abstract:

SCATS is an intelligent traffic control system owned and developed by the New South Wales Government, Australia since the 1970s. It has been applied successfully in many parts of the world, including Singapore. With the help of pavement and roadside sensors, SCATS manages the dynamic timing of traffic signal phases based on the traffic conditions in each individual intersection and the network as a whole.

4. Dynamic Traffic Assignment (DTA) Overview and Application, by Researcher Mr Yang Jiasheng (Track Leader: Prof Fwa)

Seminar Abstract:

Dynamic traffic assignment have become widely used approaches in transportation engineering because they are able to reproduce real-time queues, traveling time, throughput, actuated traffic signals, and many other traffic characteristics observed in real life. Testing road design and traffic control systems, analysis of intelligent transportation systems, evaluating traffic management schemes, and calibrating adaptive control systems are important applications of dynamic traffic assignment method. The focus of the talk will be on the overview and application of dynamic traffic assignment development.

Centre for Maritime Studies

CMS RESEARCH SEMINARS

5. A cellular automaton model for the traffic of mixed-type vessels in port water network, by Researcher Dr Wang Hua (Track Leader: A/Prof Meng Qiang)

Seminar Abstract:

The simulation of real-time vessel traffic movements is important for the port water network management and planning. We developed a cellular automaton (CA) model particularly generalized for the traffic of mixed-type vessels on waterway. Specifically, six commercial vessels and the dredging ships were taken into account. The model specifies a variety of operations of a vessel, the actions that the vessel may take during its operations, and the rules that apply to the actions by taking into account the headway distributions and domains of vessels. It should be pointed out we only consider a bi-directional mainline waterway and the ramps entering and exiting the mainline. Multi-lane waterways are not considered for the time being.

6. Adjustment of departure time and ship speed in dynamic and stochastic ocean weather environment, by Researcher Dr Chen Weidong (Track Leader: A/Prof Bressan Stephane)

Seminar Abstract:

A ship speed adjustment problem is studied when the ship is sailing in the stochastic and time dependent environment. A method can be provided to determine the optimal departure time and speed along the route.

7. Why is Singapore a successful intermodal logistics hub—An overview, by researcher Ms Song Chunxue (Track Leader: A/Prof Anthony Chin)

Seminar Abstract:

Singapore has retained its post as the biggest and busiest transshipment hub port in the world during the past years. This presentation aims to explore how the port achieve this position.

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